FINAL REPORT

MISSOURI BENCHMARKING ANALYSIS

PREPARED FOR:
The State of Missouri
The University of Missouri System
The Danforth Foundation
The Ewing Marion Kauffman Foundation

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Final Report

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INTRODUCTION

The life sciences are a rapidly growing, global industry. Countries around the world are seeking to attract and grow life science companies because they bring with them highly paid, highly skilled jobs and the potential to develop products that will dramatically improve human health and well-being. Recognizing the potential of this industry and its present geographic concentration in particular areas of the United States, states and regions are developing initiatives designed to foster an environment in which biotechnology companies can succeed and grow.

To assess Missouri's competitive position vis-à-vis other states that have established or emerging life science sectors or that are trying to develop a life science sector, Battelle benchmarked Missouri against seven other states. This analysis contains a summary of the benchmarking analysis conducted by Battelle (including Appendix A, with detailed profiles of selected states and regions). Benchmarks were selected at the *state* level to capture lessons about technology-based economic development policy, with particular attention to those states with one or more *metropolitan regions* that are active in the life sciences, so that issues of state/regional articulation could be addressed. Battelle nominated benchmark candidates in three categories: (1) states/regions that are already *winners* in the life-science race; (2) those that are active *planners* and striving to take a leading position; and (3) *peer competitors* of Missouri and its principal metro regions. The benchmark states and their respective metro regions of interest chosen by the steering committee were

Winners

- Maryland (Baltimore and Washington DC suburbs)
- North Carolina (Research Triangle and Winston-Salem)

Planners/strivers

- Pennsylvania (Philadelphia, Pittsburgh, and State College)

Peer competitors

- Illinois (Chicago, Urbana-Champaign, and Peoria)
- Ohio (Cleveland, Columbus, and Cincinnati)
- Oklahoma (Oklahoma City)
- Texas (Houston and San Antonio).

OVERVIEW OF BENCHMARK STATE/REGION STRATEGIES

The approaches taken by each of these states to grow their bioscience base and the level of state government involvement vary considerably. The strategies employed are described in the following paragraphs and summarized in Table 1.

Illinois

Illinois has launched a "VentureTECH" initiative valued at $1.9 billion, which serves as a funding umbrella for existing state programs in R&D capacity building and seed funding. The initiative is being implemented by the Illinois Coalition, a nonprofit, industry-driven technology development organization. VentureTECH also encompasses several new programs, such as the construction of research buildings at two University of Illinois campuses, the creation of commercialization centers at Northwestern University and the University of Illinois, and the acceleration of investment in venture capital by state pension funds. On a regional level, Chicago has deliberately tracked the clusters identified by the Illinois Coalition in its New Economy Strategy. Peoria has crafted a life-science strategy based on a branch-campus medical school and a USDA laboratory. Urbana-Champaign's strategy is implicit in investments made through the University of Illinois.

Maryland

Maryland has long-standing capital and operating investments in the University of Maryland Biotechnology Institute, which is designed to increase the state's R&D capacity in both Baltimore and the DC suburbs. Since the early 1990s, the state has surrounded this R&D initiative with an enhanced programmatic investment in commercialization. Elements of the "Commercial Biotechnology Strategy" include the aggressive addition of wet-lab incubation space in both metro areas, assistance to the University of Maryland for technology commercialization, creation of a wide range of publicly assisted venture-investment vehicles, efforts to foster partnerships between biotech start-ups and the region's rich set of federal laboratories, and retooling of traditional economic-development incentives to assure that they are applicable to life-science firms about to enter production.

North Carolina

Since the 1950s, the dominant strategy of the State of North Carolina has been expressed through the physical development of the Research Triangle Park and the "brand" it now represents in the life sciences. After recruiting several key federal R&D facilities in the 1980s, and sustained investment in the R&D capacity of the three participating universities, the Triangle became accepted in the 1990s as a viable location for corporate R&D. Under the "Vision 2030" strategy, attention has since turned to the development of indigenous entrepreneurial capacity, through enhanced investment in wet-lab incubators, pre-seed and early-stage venture funds with state or quasistate assistance, and continued investment in university/industry partnerships. State attention is now turning toward development of life-science assets in Winston-Salem, a secondary center of the life sciences.

Ohio

Ohio has never funded R&D capacity on a large scale; but, through its long-standing Thomas Edison Program, it does support a statewide biotechnology center with offices in four metro regions. The state also operates a flexible opportunity fund in the Governor's office and has committed a portion of its state tobacco settlement dollars for "research and technology transfer," which is likely to be spent on facility infrastructure to enhance life science research. State pension funds in Ohio have long assisted in the development of an indigenous venture-capital

sector, and the state is now moving toward the creation of earlier-stage vehicles. Each of the three major metro regions has crafted an explicit, written life-science strategy. The state has had difficulty creating value equal to more than the sum of these regional parts.

Oklahoma

Through its Center for Advancement of Science and Technology, Oklahoma operates a series of modest programs in R&D capacity building. Recently, the Governor initiated the creation of a $100 million trust fund that would increase these efforts by a significant order of magnitude. Meanwhile, the state continues to emphasize a vigorous program of commercialization assistance centers, linked to a public source of seed-stage financing. Although the main campuses of both public universities are outside Oklahoma City (as is an unusual private foundation focused on ag-biotech), Oklahoma City is where the OU Medical Center and its associated research foundation are located, and so the city has become the focal point for life-science development, including a research park with a business incubator. The city's civic leadership is focused on bioinformatics as a strategy.

Pennsylvania

Through its Ben Franklin Program, Pennsylvania has for many years emphasized collaboration between entrepreneurial start-ups and the state's research universities. However, until recently it has had no significant programs in R&D capacity building. Under the "Tech 21" strategy, the regional Ben Franklin Centers were assigned cross-cutting sectoral responsibilities. The "Life Science Greenhouse" program contemplates significant state investments ($160 million in one-time costs and $60 million annually) in R&D consortia linked to venture capital funds in three regions: Philadelphia, which leverages a big pharma community and major academic medical centers; Pittsburgh, where success in IT preceded a focus on life sciences; and State College, which remains the center of state efforts in ag-biotech.

Texas

Texas has operated a significant competitive R&D capacity program for many years, albeit somewhat out of the limelight. In the most recent biennium, the Legislature boosted funding for this program and added several ad hoc initiatives in traditional brick-and-mortar and early-stage venture financing. In general, however, the political culture of Texas does not encourage state-level planning. Rather, Austin achieved its leadership in microelectronics and software through a groundswell of civic leadership. Now, Houston and San Antonio (on a smaller scale) are emulating this approach in the life sciences. The latter already has a biotech research park, and the former is planning one, based on its heavy concentration of academic medicine facilities and entrepreneurial leadership from the president of the M.D. Anderson Cancer Center.

Table 1. Life Science Strategies/Initiatives in the Benchmark States/Regions

State/Region	Strategy or Initiative Name	Life Science Focus	Strategy Owned by This Agency/Entity	Comment
Illinois/ Statewide	VentureTECH (2001)	Part	Governor's Office and advisory board	Really a funding umbrella rather than a strategy
Illinois/ Chicago Metro	Metropolis 2020	Part	Civic Club of Chicago	More a regional plan than a strategy
Illinois/ Chicago	New Economy Strategy for Chicago (2001)	Part	Mayor's Office and advisory board	Tightly coordinated with statewide Illinois Coalition
Maryland/ Statewide	Commercial Biotechnology Strategy (1991)	Whole	Department of Business and Economic Development and TEDCO	
North Carolina/ Statewide	Vision 2030 (Encompasses a series of studies and reports)	Part	NC Board on Science and Technology	Strategy dates to 1950s, but written version is recent
Ohio/Cleveland	Creating a Biomedical Economy (2001)	Whole	Generation Foundation and NorTech (Technology Leadership Council of Cleveland Tomorrow)	
Ohio/Columbus	Central Ohio Bioscience Strategy (2000)	Whole	Columbus Technology Leadership Council and Edison Biotech Center	
Ohio/Cincinnati	Life Science Task Force (1999)	Whole	BIO/START incubator	Has not moved forward
Pennsylvania/ Statewide	Tech 21 and Life Science Greenhouse	Part	Office of the Governor/ Pennsylvania Technological Development Authority	
Pennsylvania/ Philadelphia	Greater Philadelphia's Knowledge Industry (2000)	Part	Pennsylvania Economy League, Greater Philadelphia First, Eastern Technology Council	
Pennsylvania/ Pittsburgh	Working Together	Part	Allegheny Conference on Community and Economic Development, Pennsylvania Economy League, and Pittsburgh Regional Alliance	More a regional plan than a technology strategy, but has led to projects

MISSOURI'S COMPETITIVE POSITION

To create an environment in which bioscience firms can grow and flourish, states and regions are undertaking initiatives that seek to address the specific needs of bioscience companies. These include

- Strong academic research institutions conducting basic research in the biosciences
- Mechanisms for successful transfer of basic research for product commercialization
- Access to early-stage risk capital
- Specialized facilities, including wet laboratory space and specialized equipment
- Stable and supportive tax and regulatory policies
- A supply of highly skilled workers with training in the biosciences.

This section compares Missouri's current infrastructure in each of these areas to those of the benchmark states and then describes the initiatives undertaken in the benchmark states to address each need.

Bioscience Research and Development Base

Bioscience Industrial Base

Missouri had more than 1,800 bioscience establishments (companies) in 2001 employing more than 193,000 people, ranking it fifth among the benchmark states in establishments and sixth in employment. However, with a 35 percent increase in bioscience establishments from 1995 to 2001, Missouri had the fourth-highest growth rate in the comparison set and surpassed the U.S. growth rate by 2.4 percentage points. With an 11 percent increase in bioscience employment, Missouri had the third highest growth rate among the benchmark states and exceeded the U.S. growth rate by 3.7 percentage points. Additionally, with a location quotient of 1.14,[1] Missouri shows a slight relative concentration in the bioscience industry, ranking second among the benchmark states (see Table 2).

[1] Location quotients are a common measure of the concentration (usually as measured by employment) of a particular industry sector in a region, relative to a reference area. A location quotient greater than 1 signifies relative specialization in an industry relative to the United States as a whole; less than 1 signifies under-representation. Location quotients greater than 1.2 are considered to represent a notable degree of specialization.

Table 2. Private Sector Bioscience Industry Data

	Bioscience Establishments, 2001	Est. % Change, 1995-2001	Bioscience Employment, 2001	Emp. % Change, 1995-2001	Location Quotient, 2001	Employees/ Establishment
Illinois*	2,524	15.3	333,599	4.6	1.09	132
Maryland	1,468	35.2	129,032	14.5	0.88	88
Missouri*	**1,815**	**34.8**	**193,117**	**11**	***1.14***	**106**
North Carolina	1,729	69.0	195,006	18.8	0.99	113
Ohio	2,438	30.4	300,143	2.2	1.04	123
Oklahoma	802	25.6	84,941	–10.1	1.08	106
Pennsylvania	3,187	36.5	385,747	2.0	*1.27*	121
Texas	4,926	39.4	438,892	10.7	0.89	89
United States	68,781	32.4	6,810,918	7.3	1.00	99

*Note: Missouri includes the portions of metropolitan St. Louis and Kansas City that fall in Illinois and Kansas. Illinois excludes the portion of metropolitan St. Louis that is located within the state's boundaries.

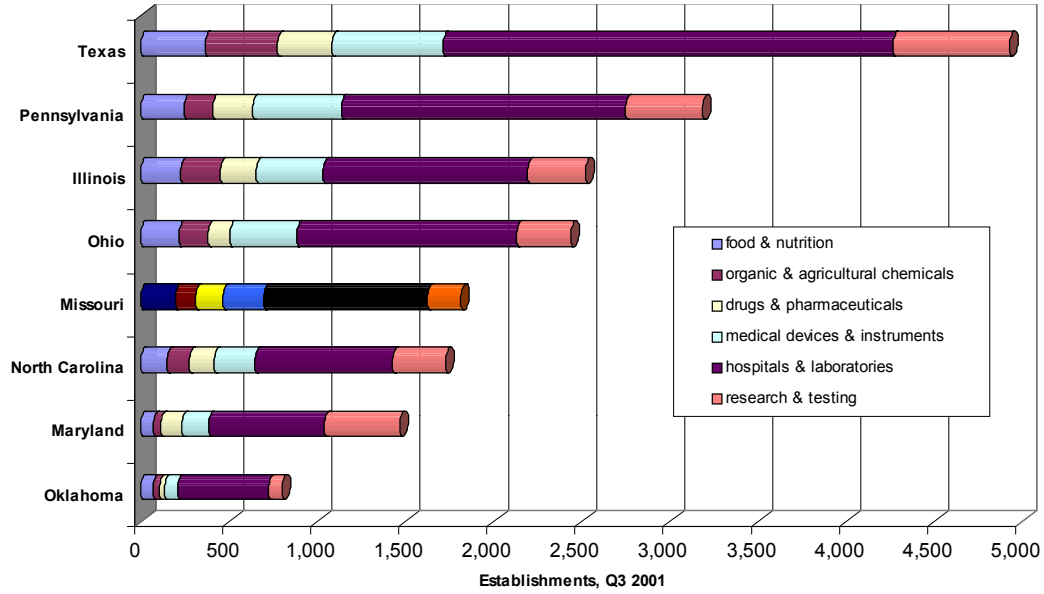
Note: Italics indicate significant concentrations (location quotients equal to or greater than 1.2).

Source: Dun & Bradstreet *MarketPlace* 1995 (Q4) and 2001 (Q3), Battelle calculations. Bioscience is defined to include food and nutrition (SIC 2021-2026, 2048, 2074-2079), organic and agricultural chemicals (SIC 2824, 2844, 2869, 2879), drugs and pharmaceuticals (SIC 2833-2836), medical devices and instruments (SIC 3559-9922, 3821, 3826, 3841, 3842, 3844, 3845), hospitals and laboratories (SIC 8062, 8069, 8071), and bioscience research and testing (SIC 8731-01, 8731-9902, 8733-01, 8734-9903, 8734-9908,8734-9910, and portions of 8731-0000, 8731-0202, 8732-0108, 8733-8802, 8733-9904, 8734-0000. Partial inclusion of SIC categories in bioscience research and testing is based on examination of Missouri establishments and local information sources; partial inclusion in other states and for the U.S. uses the inclusion ratios determined for Missouri.

Viewed by subsector, every one of the benchmark states has the highest absolute number of establishments (Figure 1) and employment (Figure 2) in the hospital and laboratory subsector. Generally, the composition by subsector seems to be proportional to the overall size of the sector, although some anomalies are visible. For example, compared with the overall size of the bioscience sector, Missouri seems to have a relatively small number of establishments in both the devices and instruments subsector and the research and testing subsector. Moreover, its employment base is overwhelmingly in the hospital and laboratory subsector.

Location quotients for key subsectors (see Table 3) show that Missouri is relatively specialized in three bioscience industry subsectors. The food and nutrition subsector shows a relatively high concentration, but only 0.4 percent growth from 1995 to 2001, similar to the national pattern. The subsector for organic and agricultural chemicals also shows a relative concentration as well, but also flat growth. High specializations combined with flat or declining growth could suggest a move toward other parts of the country and could foretell a less-powerful specialization in the future. As noted previously, the hospitals and laboratories subsector is also highly concentrated, and it exhibits a growth rate of almost 18 percent over the reference period, far stronger than national growth.

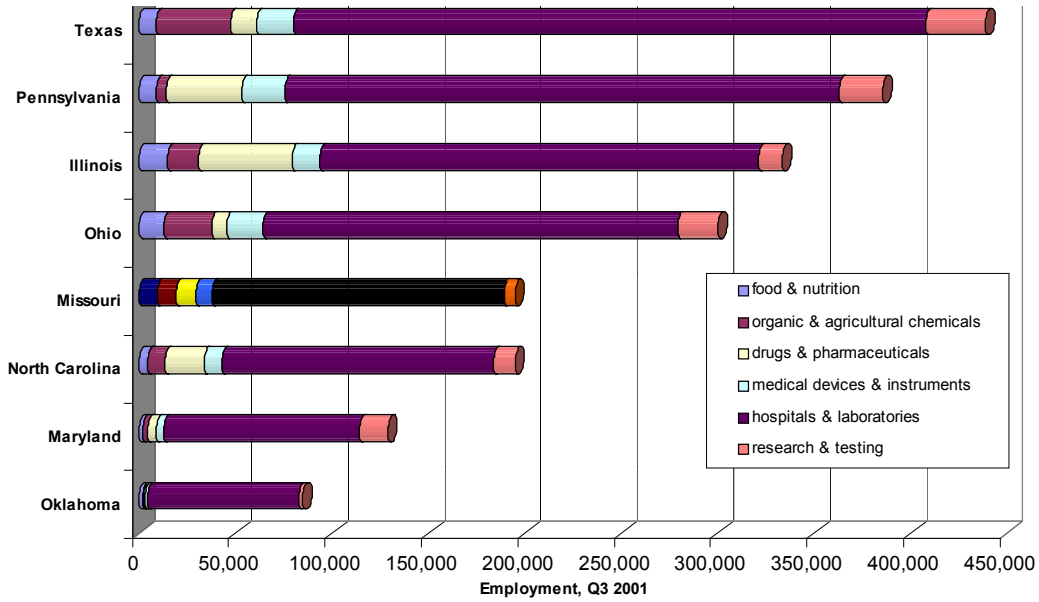
Figure 1. Private Sector Bioscience Establishments by Subsector



Note: Missouri includes metro St. Louis and Kansas City; Illinois excludes metro St. Louis.

Source: D&B *MarketPlace* and Battelle calculations.

Figure 2. Private Sector Bioscience Employment by Subsector



Note: Missouri includes metro St. Louis and Kansas City; Illinois excludes metro St. Louis.

Source: D&B *MarketPlace* and Battelle calculations.

Table 3. Private Sector Bioscience Subsector Concentrations (Location Quotients) and Employment Growth, 1995-2001

	Food & Nutrition		Organic & Agric. Chem.		Drugs & Pharm.		Medical Dev. & Instruments		Hospitals & Laboratories		Research & Testing	
	LQ	% Emp Ch	LQ	% Emp Ch	LQ	% Emp Ch	LQ	% Emp Ch	LQ	% Emp Ch	LQ	% Emp Ch
Illinois*	*1.66*	15.0	*1.26*	–3.6	*2.46*	70.6	0.76	17.1	1.01	–5.3	0.65	52.7
Maryland	0.45	–18.5	0.43	171.2	0.46	16.9	0.45	16.6	0.93	13.1	*1.65*	17.1
Missouri*	***1.90***	**0.4**	***1.11***	**1.3**	**0.95**	**–28.7**	**0.76**	**–7.4**	***1.20***	**17.5**	**0.58**	**27.4**
North Carolina	0.76	–11.6	1.09	–41.1	*1.60*	18.2	0.75	24.9	0.97	23.2	0.94	129.0
Ohio	*1.54*	12.6	*2.03*	20.3	0.42	100.0	1.06	27.5	1.01	–8.7	1.19	177.2
Oklahoma	0.77	–21.2	0.14	–24.5	0.16	35.0	0.32	15.3	*1.34*	–10.4	0.39	–12.8
Pennsylvania	1.05	–4.9	0.38	–6.1	*2.02*	61.7	1.16	23.4	*1.28*	–6.9	*1.23*	85.8
Texas	0.64	3.6	*1.84*	26.1	0.44	48.6	0.61	–19.6	0.90	10.2	1.03	13.7
United States	1.00	0.3	1.00	–1.5	1.00	39.0	1.00	13.1	1.00	3.8	1.00	36.2

* Missouri includes the portions of metropolitan St. Louis and Kansas City that fall in Illinois and Kansas. Illinois excludes the portion of metropolitan St. Louis that is located within the state's boundaries.

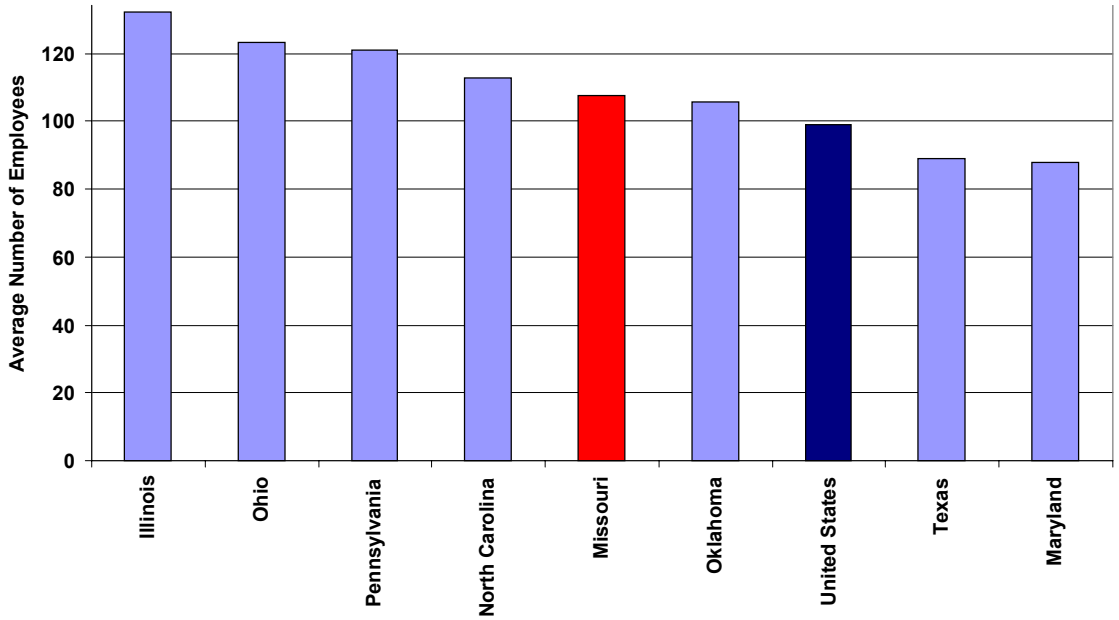
Note: Italics indicate significant concentrations (location quotients equal to or greater than 1.2).

Source: Dun & Bradstreet *MarketPlace* 1995 (Q4) and 2001 (Q3), Battelle calculations. Bioscience is defined to include food and nutrition (SIC 2021-2026, 2048, 2074-2079), organic and agricultural chemicals (SIC 2824, 2844, 2869, 2879), drugs and pharmaceuticals (SIC 2833-2836), medical devices and instruments (SIC 3559-9922, 3821, 3826, 3841, 3842, 3844, 3845), hospitals and laboratories (SIC 8062, 8069, 8071), and bioscience research and testing (SIC 8731-01, 8731-9902, 8733-01, 8734-9903, 8734-9908, 8734-9910, and portions of 8731-0000, 8731-0202, 8732-0108, 8733-9902, 8733-9904, 8734-0000). Partial inclusion of SIC categories in bioscience research and testing is based on examination of Missouri establishments and local information sources; partial inclusion in other states and for the U.S. uses the inclusion ratios determined for Missouri.

The story in the remaining subsectors is mixed. The drugs and pharmaceuticals subsector—one usually deemed to have the closest relationship to the biotechnology business—declined significantly in Missouri over the reference period and exhibited relatively low concentration. Research and testing, the other subsector related to biotechnology, also shows a relatively low concentration of employment, but grew significantly by almost 28 percent over the reference period. In research and testing, only Maryland and Pennsylvania among the benchmark states showed significant specialization. Illinois, North Carolina, and Pennsylvania all showed significant concentrations in the drugs and pharmaceuticals subsector.

Missouri ranks fifth among the benchmark states in the number of employees per bioscience firm (see Figure 3). It exceeds the U.S. average by 8, suggesting that many of the bioscience companies in the State of Missouri are relatively large in size.

Figure 3. Average Employees per Bioscience Establishment



Note: Missouri includes metropolitan St. Louis and Kansas City; Illinois excludes metropolitan St. Louis.

Academic Bioscience R&D Base

Data from the period FY 1995 to FY 1999 (Table 4) show that Missouri's academic R&D spending is far more specialized in bioscience than is that in the United States as a whole or any of the benchmark states. Fully 82 percent of academic R&D in Missouri is classified as bioscience, totaling more than $2 billion annually.

Figure 4 shows that, among the several subsectors of bioscience R&D, the largest shares for Missouri are in medical sciences (36 percent) and biological sciences (31) percent.

Table 4. Academic R&D, FY 1995-1999

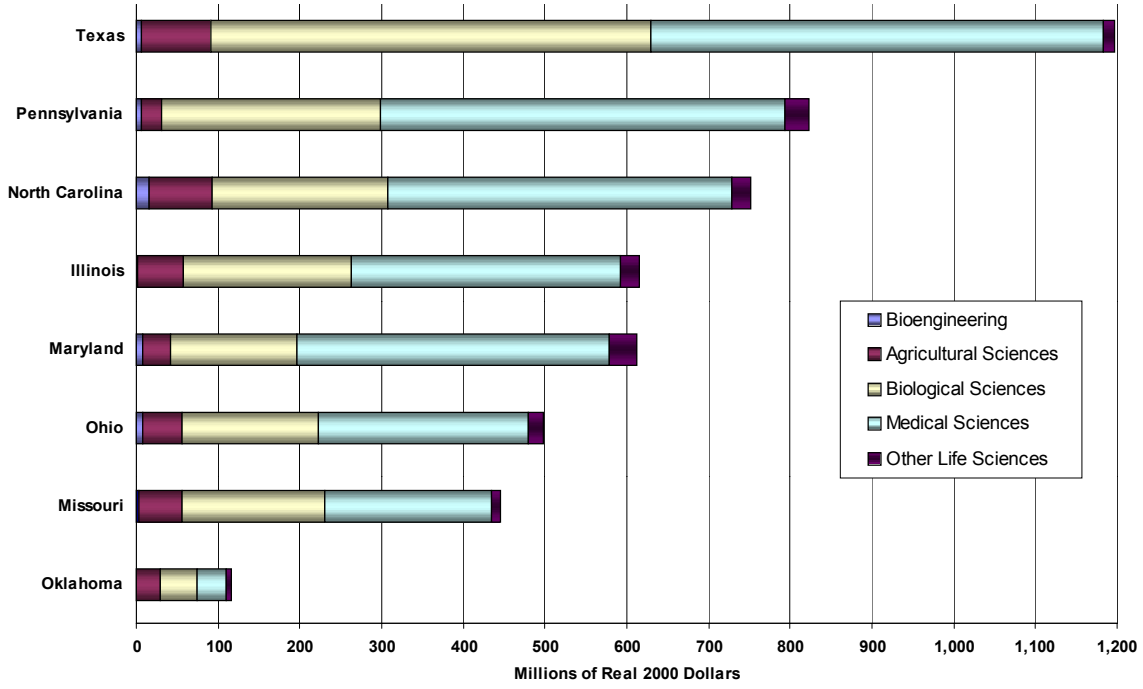
	Bioscience R&D Dollars	% of All Academic R&D	Annual Bioscience R&D per Capita	% Change R&D FY '95-'99	% Change per Capita FY '95-'99
Illinois	$2,714,937	52.6%	$45	26.9%	19.6%
Maryland	$2,882,657	41.5%	$113	11.3%	7.5%
Missouri	**$2,044,380**	**82.3%**	**$76**	**27.4%**	**19.4%**
North Carolina	$3,170,451	70.1%	$85	33.6%	20.3%
Ohio	$2,260,444	56.1%	$40	31.2%	23.1%
Oklahoma	$840,626	51.0%	$51	8.3%	5.1%
Pennsylvania	$3,813,383	56.0%	$63	18.9%	16.2%
Texas	$5,369,507	60.7%	$55	18.1%	9.1%
United States	*$73,966,022*	*56.2%*	*$55*	*18.3%*	*12.3%*

Note: Bioscience R&D dollars are in thousands of real 2000 dollars.

Note: Southern Illinois University is included within the State of Illinois above, although the university is located within the St. Louis metropolitan area; Southern Illinois University reported only $910,000 in bioscience R&D from 1995-1999.

Source: National Science Foundation, Survey of R&D Expenditures at Universities and Colleges.

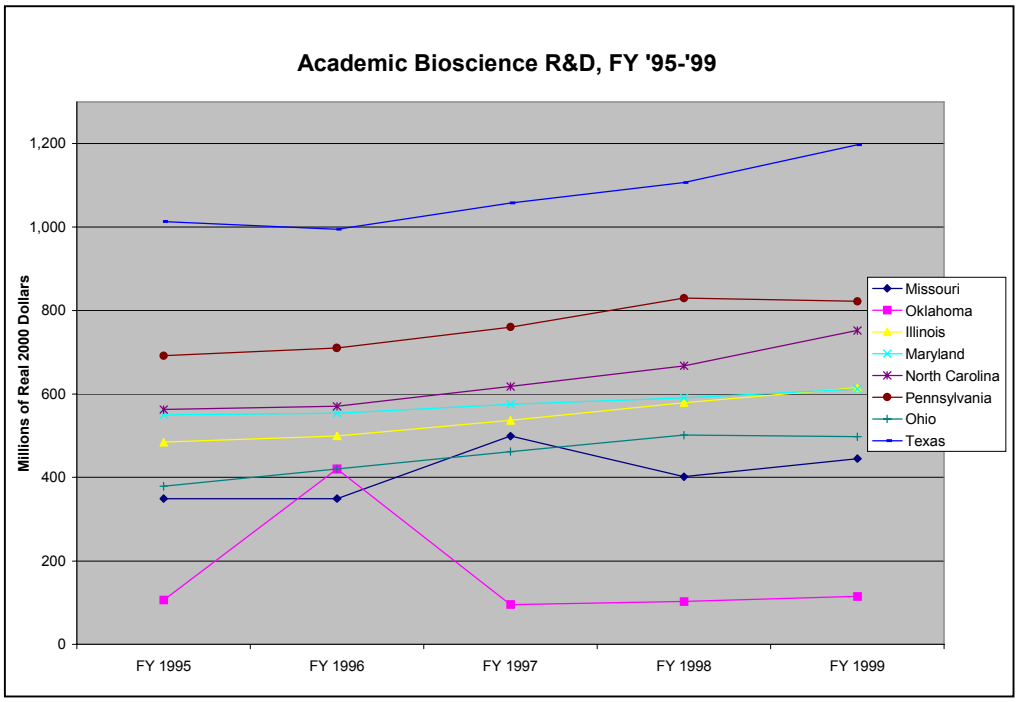
Figure 4. Academic Bioscience R&D by Discipline, FY 1999



Note: Southern Illinois University is included within the State of Illinois above, although it is in the St. Louis MSA; Southern Illinois has only $910,000 in bioscience R&D in the entire range 1995-1999.

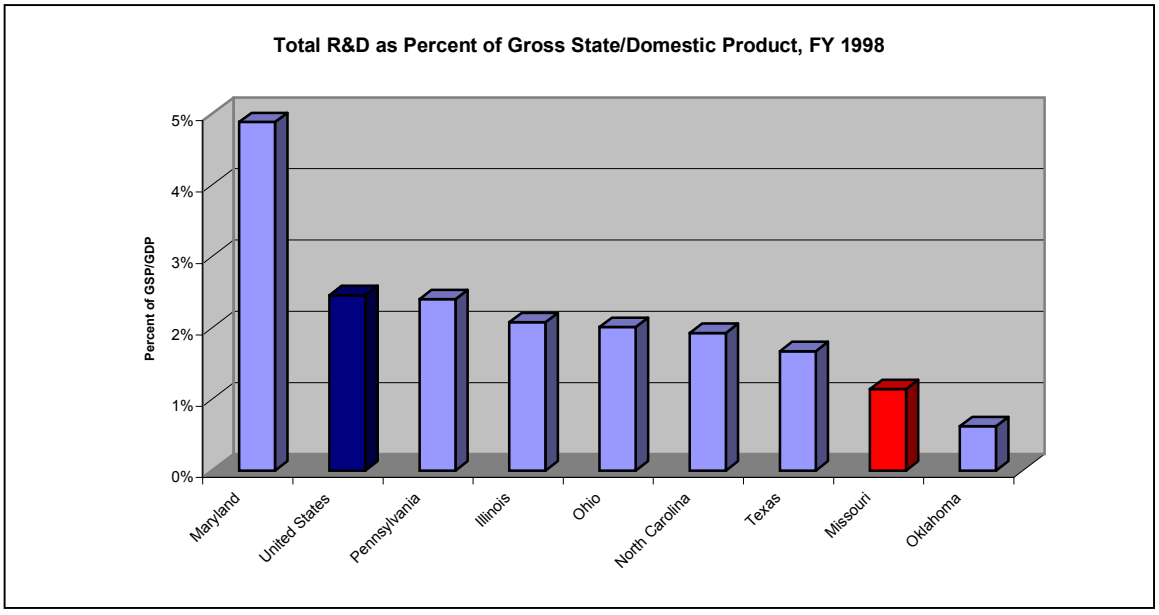
Figure 5 shows that, during this period, Missouri showed healthy growth rates in R&D funding (third highest), although the absolute level was second to last among the benchmarks.

Figure 5. Academic Bioscience R&D, FY 1995-1999



Normalizing total academic R&D by gross state product (Figure 6) shows that Missouri ranks seventh among the benchmarks and behind the United States as a whole.

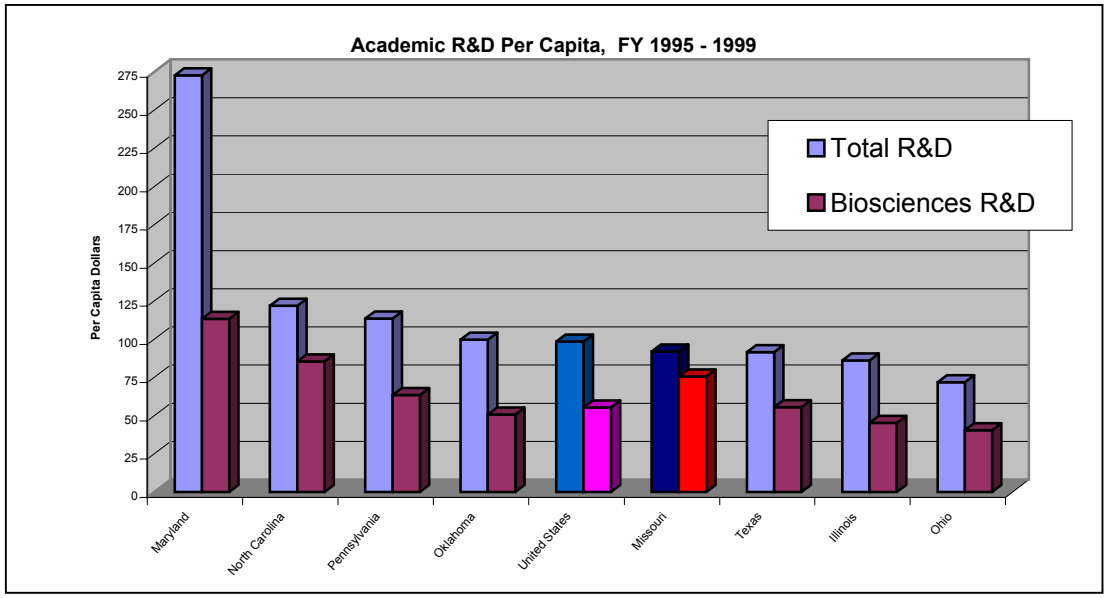
Figure 6. Total R&D as Percent of Gross State Domestic Product, FY 1998



Source: National Science Foundation, National Patterns of R&D Resources.

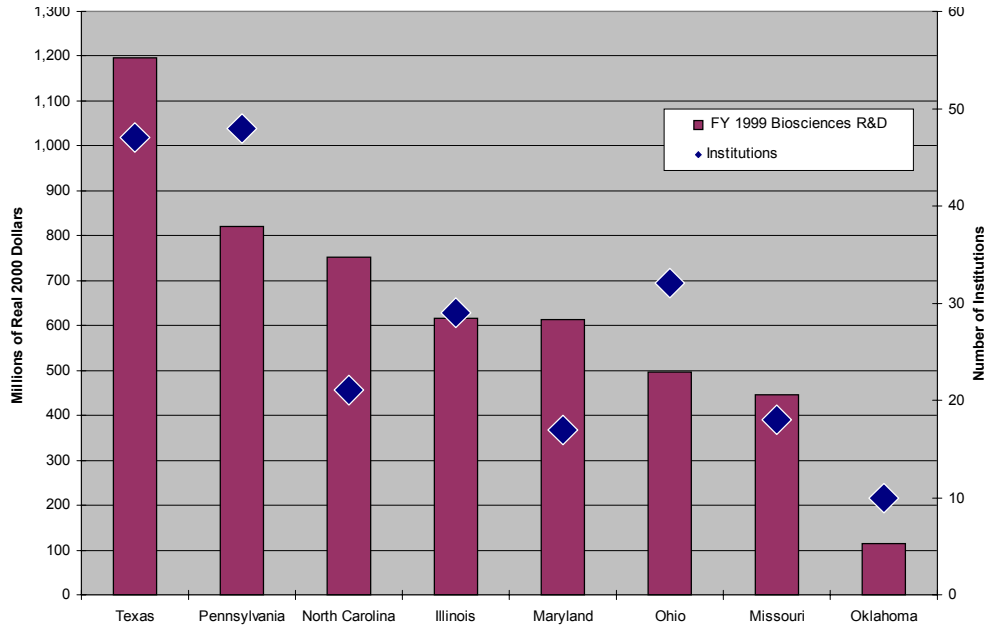
Adjusting these same data per capita (see Figure 7) shows that, although Missouri ranks only fifth among the benchmarks in total R&D, it ranks third in bioscience R&D. At $76 per capita for bioscience research, Missouri surpasses the next highest state, Pennsylvania, by $13 per capita.

Figure 7. Academic R&D per Capita, FY 1995-1999



A chart of data from the most recent single year for which data are available (Figure 8) shows that Missouri ranked seventh, with $450 million in bioscience R&D distributed over 18 academic institutions. By comparison, with one less institution receiving funding, Maryland had more than $610 million in funding, or a higher average amount per institution, ranking fifth.

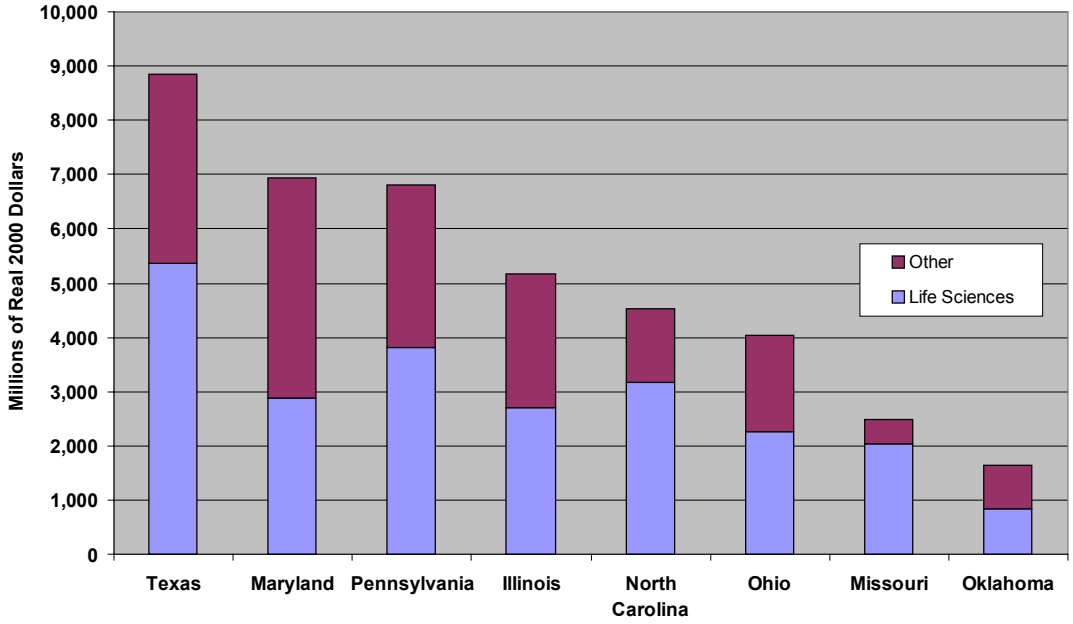
Figure 8. Academic Bioscience R&D with Institution Count, FY 1999



Note: Southern Illinois University is included within the State of Illinois above, although it is in the St. Louis MSA. Source: NSF Survey of R&D Expenditures at Universities and Colleges.

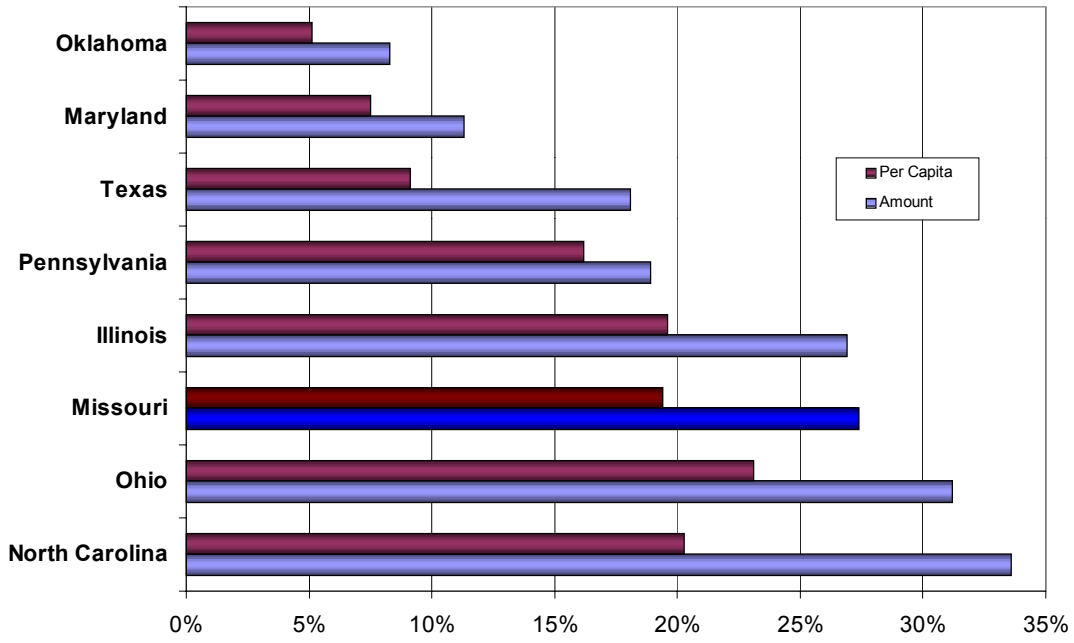
Figure 9 shows that, as a percentage of total academic R&D, Missouri is the most specialized in the life sciences among the benchmark set.

Figure 9. Life Science and Total Academic R&D, FY 1995-1999



Indeed, Figure 10 shows that Missouri's life science academic R&D is growing faster—both in absolute and per capita terms—than most of the benchmarks.

Figure 10. Percent Change in Life Science Academic R&D, FY 1995-1999



One very important component of bioscience R&D is funding from the National Institutes of Health (NIH). Table 5 shows that, with only about $367 million in NIH funding in FY 2000, Missouri trails the highest state, Pennsylvania, by almost $580 million, placing it seventh among the benchmark states.

Table 5. National Institutes of Health Awards, FY 1997-2000

	FY 2000				% Change FY 1997-2000	
	Grants	Amount	State Rank	Per Capita	Amount	Per Capita
Illinois	1,611	$473,148,806	9	$38	37.4%	32.9%
Maryland	2,063	$868,641,136	5	$164	27.0%	22.1%
Missouri	**1,069**	**$366,949,801**	**12**	**$66**	**38.6%**	**34.0%**
North Carolina	1,585	$581,097,379	7	$72	27.6%	17.8%
Ohio	1,538	$463,886,400	10	$41	33.7%	32.0%
Oklahoma	157	$44,429,048	37	$13	32.4%	27.1%
Pennsylvania	2,936	$946,261,320	4	$77	29.4%	26.6%
Texas	2,325	$765,113,382	6	$37	39.5%	29.5%
United States	*43,991*	*$14,571,522,427*	*n.a.*	*$52*	*30.8%*	*24.5%*

Note: Bioscience R&D Dollars are in thousands of real 2000 dollars.
Source: National Institutes of Health; United States Census Bureau (population); Battelle calculations.
Note: The Illinois portion of the St. Louis metropolitan area is included in Illinois and the Kansas portion of the Kansas City metropolitan area is not included.

However, on a per capita basis, Missouri ranks fourth among the benchmark states and surpasses the United States by $14 per capita, increasing 34 percent during the period 1997-2000.

One reason for this strong result is that, among Missouri institutions (Table 6), Washington University ranks fifth in the country in total dollars from the NIH. The University of Missouri is a favorable 98th among the more than 2,500 institutions that receive some NIH support.

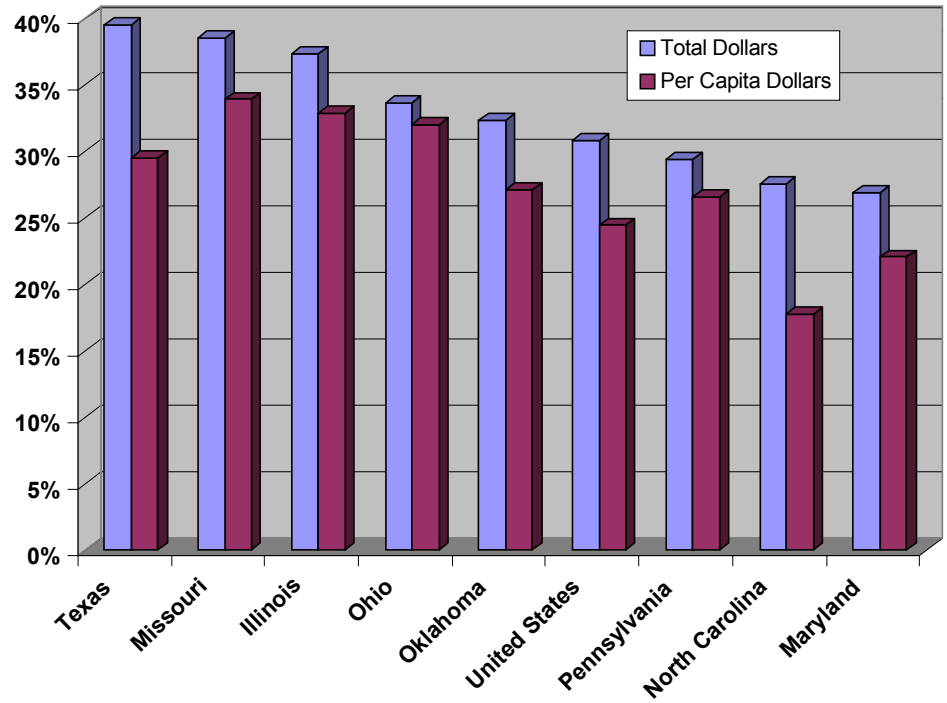
Table 6. NIH Grants to Missouri, Metropolitan St. Louis, and Kansas City Institutions, FY 2000

Institution	Total Grants	Total Amount	Institutional Rank	Research Grants	Research Amount	Institutional Rank
Washington University	710	$279,478,547	5	628	$258,540,029	5
University of Kansas system	160	$43,628,711	84	141	$39,679,655	83
University of Missouri	166	$34,207,377	98	147	$31,456,552	96
St. Louis University	90	$21,574,038	129	81	$20,267,114	127
Barnes-Jewish Hospital	60	$16,670,003	144	58	$15,901,686	139
Midwest Research Institute	4	$6,077,290	260	0	$0	2,301
Southern Illinois University at Edwardsville	2	$122,433	1,876	2	$122,433	1,573

Note: Ranks are for U.S. institutions only: 2,407 total institutions.
Note: The Illinois portion of the St. Louis metropolitan area is included in Illinois and the Kansas portion of the Kansas City metropolitan area is not included.
Note: The University of Kansas Medical Center is grouped with the overall University of Kansas system.
Source: National Institutes of Health.

Overall, during the period FY 1997 to FY 2000, Missouri experienced extremely rapid growth in NIH funding, compared with the benchmark set. Figure 11 shows that the growth rate in dollars was second only to that of Texas, and that the growth rate in per capita funding was the highest in the set, exceeding the national average by nearly 10 percentage points.

Figure 11. Percent Change in NIH Dollars, Total and Per Capita, FY 1997-2000



Note: The Illinois portion of the St. Louis MSA is included in Illinois, and the Kansas portion of the Kansas City MSA is not included.

Source: NIH.

R&D Initiatives in the Benchmark States/Regions

Five of the benchmark states have developed explicit initiatives to increase the level of bioscience R&D captured by their academic and research institutions (see Table 7 following this text). These initiatives transcend existing formula-based support to the public university system and its research programs. They do not support research for its own sake—duplicating the NIH or NSF at the state level—but rather attempt to use state support as a lever to achieve several interrelated objectives:

- Expansion of physical capacity for bioscience research (i.e., laboratory buildings or specialized equipment that cannot be bought on federal grants but is necessary to obtain them), allowing the state to "track" expected growth in funding from the NIH or even expand its market share
- Development of research faculty, including both start-up assistance to junior faculty who might one day become large federal grantees and "packages" necessary to attract more senior faculty who bring with them existing large portfolios of federal funding

- Creation of links between academic disciplines and among various research institutions, allowing access to federal programs that favor such cooperation or that require a wider range of intellectual or physical resources than any one institution can provide
- Provision of matching funds to attract federal R&D support that requires state or local matching
- Development of a cadre of well-trained graduate students and postdoctoral students who upon leaving academia may form the nucleus for a range of entrepreneurial life-science start-ups
- General improvement in the reputation of the state as a center of the biosciences, enhancing its legitimacy in the eyes of those executives who determine the placement of R&D investments by large corporations.

There is a wide range of approaches to these goals. The largest and longest-standing initiative is the University of Maryland Biotechnology Institute, created as a freestanding unit of the state university system precisely to attract federal R&D funding. Many other programs of similar vintage are modest, peer-reviewed programs—such as the Research and Institutional Development Grants offered by the state-supported North Carolina Biotechnology Center, or the Advanced Research/Technology Awards of the Texas Higher Education Coordinating Board. In recent years, there has been a trend toward larger and more flexible (politically driven) capacity-building efforts, such as Ohio's discretionary Technology Action Fund, the "bricks and mortar" component that is built into Illinois's VentureTECH, or the line-item package in Texas. Even Oklahoma, which has offered a modest grant program for some time, is now contemplating a larger effort with a $100 million endowment.

Table 7. Bioscience R&D Initiatives in the Benchmark States/Regions

State/Region	Initiative	Life Science Focus	Agency/Funding	Comment
Illinois/ Statewide	Technology Challenge Grant (mid-1980s)	Part	$4.2 million discretionary fund from Department of Commerce and Community Affairs	
	Centers for Academic Excellence (2001)	Part	VentureTECH component funding	Exclusive focus on teaching hospitals
	"Bricks and Mortar" for R&D facilities (2001)	Part	Direct appropriation $200+ million in projects	Chicago and Urbana-Champaign
Maryland/ Statewide	University of Maryland Biotechnology Institute (since mid-1980s)	Whole	Direct appropriation	Facilities in Baltimore, College Park, and Shady Grove/Rockville
North Carolina/ Statewide	Research and Institutional Development Grants	Whole	NC Biotechnology Center (1980s)	Usually supports universities in Triangle area, and also in Winston-Salem

Table 7. Bioscience R&D Initiatives in the Benchmark States/Regions (continued)

State/Region	Initiative	Life Science Focus	Agency/Funding	Comment
Ohio/Statewide	Technology Action Fund (1990s)	Part	Governor's Office. $15 million	Opportunity funding distributed across the state
	Hayes Investment Fund	Part	Regents	Aimed at inter-institutional collaboration
	Research Challenge Fund	Part	Line items totaling $19 million	Research support
Oklahoma/ Statewide	Oklahoma Health Research Program (1990s)	Whole	Oklahoma Center for Advancement of Science and Technology (1980s)	Up to $45,000 per year
	Oklahoma Institute of Technology (still taking shape)	Part	Established in 2001 with $1 million trust fund; aiming at $100 million endowment	Intended to coordinate and fund major research initiatives
Pennsylvania/ Statewide-Regional	Life Science Greenhouse	Whole	$160 million one-time, $60 million annually	One center each in Philadelphia, Pittsburgh, and State College
Texas/ Statewide	Advanced Research/ Advanced Technology Program (1990s)	Part	Higher Education Coordinating Board. $60 million	Grants. Increments of $50,000. Limitation on total awards/investigator
	$385 million appropriations package in 2001	Part	Direct appropriations	Includes support for San Antonio Life Sciences Institute
	Excellence Fund and University Research Fund (2001)	Part	$34 million to $50 million	Financed from return on state's higher education investment fund

Knowledge Transfer and Commercialization

Analysis

One measure of the efficiency of "knowledge transfer" from the university research enterprise is the annual survey of The Association of University Technology Managers (AUTM). AUTM's survey for FY 1999 included data for approximately 140 universities, including Washington University, the University of Missouri System, and Saint Louis University. Table 8 shows measures of technology transfer for these participating universities. As might be expected based on their size, Washington University and the University of Missouri system exceed the medians reported by survey participants in several categories. Washington University's four start-ups are particularly notable. Normalizing the results by the size of each institution's R&D budget (i.e., per $10 million of sponsored R&D), Washington University's performance is still impressive, but the University of Missouri's is less so. Adjusting for its smaller size, Saint Louis University beats the median in both disclosures and patents issued. Table 9 shows the same variables for only the two larger institutions, cumulated over the period FY 1996 through FY 1999.

Table 8. Missouri Universities Technology Transfer Activity, FY 1999

	Washington University	University of Missouri System	St. Louis University	AUTM Median	AUTM Top Quartile
Sponsored Research Expenditures	$344,395,866	$219,372,880	$28,752,025	$118,891,387	$215,542,561
Invention Disclosures	104	62	19	46	95
Patent Applications Filed	78	37	15	35	73
Patents Issued	**39**	**22**	**6**	**13**	**28**
Licenses and Options Executed	114	16	3	10	25
Licenses Yielding Income	**107**	**21**	**22**	**20**	**48**
Gross License Income	**$7,350,932**	**$1,596,917**	**$814,975**	**$814,975**	**$3,396,725**
Start-Ups	**4**	**1**	**0**	**1**	**3**
Disclosures per $10 million R&D	3.02	2.83	6.61	3.86	5.20
Patents Issued per $10 million R&D	1.13	1.00	2.09	1.01	1.80
Licenses Executed per $10 million R&D	3.31	0.73	1.04	1.04	1.44
Average Income per License	$68,700	$76,044	$37,044	$34,706	$80,289
Start-Ups per $10 million R&D	0.12	0.05	0.00	0.07	0.17
Start-Ups per License Executed	0.04	0.06	0.00	0.06	0.17

Note: All dollar amounts are real 2000 dollars.

Note: The University of Kansas Medical Center is not included because it is grouped with the overall University of Kansas system.

Source: Association of University Technology Managers (AUTM) survey, Battelle calculations.

Table 9. Missouri Universities Technology Transfer Activity, FY 1996-1999

	Washington University	University of Missouri System	AUTM Median	AUTM Top Quartile
Sponsored Research Expenditures	$1,195,140,521	$717,830,399	$597,199,049	$936,505,150
Invention Disclosures	210	244	220	419
Patent Applications Filed	296	124	133	274
Patents Issued	**118**	**57**	**52**	**100**
Licenses and Options Executed	243	68	46	130
Licenses Yielding Income	**450**	**73**	**102**	**238**
Gross License Income	**$29,189,351**	**$6,206,373**	**$4,960,480**	**$16,137,559**
Start-Ups	9	1	5	12
Disclosures per $10 million R&D	1.76	3.40	4.21	5.32
Patents Issued per $10 million R&D	0.99	0.79	1.00	1.52
Licenses Executed per $10 million R&D	2.03	0.95	0.95	1.72
Average Income per License	**$64,865**	**$85,019**	**$42,632**	**$72,153**
Start-Ups per $10 million R&D	0.08	0.01	0.09	0.16
Start-Ups per License Executed	0.04	0.01	0.10	0.15

Note: All dollar amounts are real 2000 dollars.
Source: Association of University Technology Managers (AUTM) survey, Battelle calculations.

Another important measure is the overall number of patents issued in a region, regardless of their source (that is, from an academic, industrial, or independent inventor). On this measure, Table 10 shows that Missouri ranks seventh in the number of bioscience patents[2] issued to its inventors in both FY 2000 and the period from FY 1996 to FY 2000. Patent issuance increased 36 percent over this period, but this growth rate lagged the nation's as a whole and about half the benchmark set. However, Missouri's bioscience patents went from 24 percent to 26 percent of its total, staying ahead of the national average and maintaining a rank of second in the benchmark set. While Missouri's share of all U.S. bioscience patents declined from 1996 to 2000, most of the benchmarked states experienced similar declines, and at sharper rates than those of Missouri.

[2] The definition of bioscience-related patents as used in this analysis is described using the U.S. Patent and Trademark Office Classification system numbers in Table 10's adjoining box.

Table 10. Bioscience-Related Patents, FY 1996-2000

	Bioscience Related Patents FY '00	Avg. Bioscience Patents '96-'00	Percent Change of Bioscience Patents '96-'00	Bioscience Related Patents as a % of All Patents FY '96	Bioscience Related Patents as a % of All Patents FY '00	State Share of Total U.S. Bioscience Patents 1996	State Share of Total U.S. Bioscience Patents 2000
Illinois	656	568	28.1%	16.3%	17.1%	4.6%	3.9%
Maryland	499	494	51.7%	29.9%	36.8%	2.9%	3.0%
Missouri	**213**	**218**	**35.7%**	**23.9%**	**25.9%**	**1.4%**	**1.3%**
North Carolina	327	287	45.3%	18.9%	17.7%	2.0%	1.9%
Ohio	548	536	30.8%	16.0%	17.1%	3.8%	3.3%
Oklahoma	94	89	11.9%	17.5%	17.3%	0.8%	0.6%
Pennsylvania	834	762	38.8%	20.6%	22.9%	5.4%	5.0%
Texas	788	671	63.8%	11.5%	12.5%	4.3%	4.7%
United States	*16,777*	*15,102*	*50.3%*	*18.3%*	*19.7%*	*100.0%*	*100.0%*

Note: Bioscience-related patent classifications are detailed in adjoining box.

Source: United States Patent and Trademark Office

Bioscience-Related Patent Classifications

- 047 – Plant Husbandry
- 071 – Fertilizers
- 119 – Animal Husbandry
- 127 – Sugar, Starch, & Carbohydrates
- 128 – Surgery
- 131 – Tobacco
- 137 – Fluid Handling
- 260 – Carbon Compound Chemistry
- 351 – Optics
- 369 – Dynamic Info Storage & Retrieval
- 422 – Chemical Preserving & Sterilizing
- 424 – Drugs
- 426 – Foods
- 430 – Radiation Imagery Chemistry
- 433 – Dentistry
- 435 – Molecular Biology & Microbiology
- 436 – Analytical Chemistry
- 449 – Bee Culture
- 504 – Plant-Affecting Compositions
- 512 – Perfume Compositions
- 514 – Drugs
- 530 – Resins & Derivatives
- 585 – Hydrocarbon Chemistry
- 600-607 – Surgery Applications
- 623 – Prostheses
- 707 – Database & File Management
- 717 – Data Processing Software
- 800 – Multicellular Living Organisms
- 930 – Peptide & Protein Sequences

Initiatives

Distinct from the objective of building R&D *capacity* is the objective of encouraging research that is conducted jointly among academia and the regional industrial base. Joint research leads to the transfer of knowledge and technology into the regional economy, and can encourage the placement of spin-offs within the jurisdiction, rather than acceptance of passive out-licensing of technology to distant users. To make this kind of research happen, it is usually necessary to finance outside the mainstream of peer-reviewed, federally funded academic research. A frequent mechanism is a state-provided or state-financed partnership grant, intended to support joint, "directed" basic research. Often such grants are repayable on certain conditions by the private-sector partner who may commercialize the results of the research. Statewide programs of this kind operate in Maryland, North Carolina, Ohio, Oklahoma, and Texas. In addition, the Pennsylvania program delivers this service on a regional, decentralized basis, with the additional wrinkle that the grants are *repayable*. Sometimes, public universities themselves develop internal versions of these challenge grants, such as at the University of Maryland.

Although university/industry partnerships are useful for ensuring the transfer of knowledge, they do not necessarily meet all the needs involved in commercializing a technology owned by a research institution. Often university-owned IP derives not from industry sponsorship, but from conventional federal research support. Particularly in cases where a spin-off is the contemplated commercialization vehicle, research institutions have a strong and unmet need for funds to carry on activities such as feasibility studies, proof-of-concept tests, prototype production, market or business planning, and other reduction-to-practice challenges. Again, these needs are not appropriate to conventional sources of federal (or industrial) R&D funding. Many states in the benchmark set have therefore developed mechanisms to provide this funding to universities. Examples include Maryland's Technology Development Fund and North Carolina Biotech Center's "Proof of Principle" awards. Some universities have developed these mechanisms internally. For example, the University of Chicago's tech transfer office "invests" in commercialization research, and Baylor College of Medicine has created a for-profit commercialization company to do so.

The line between these commercialization programs and early-stage sources of risk capital is not always clear. In general, commercialization programs focus on pushing technology out of the research institution, while risk-capital programs focus on formation of start-up companies that may or may not "pull" technology from a university. In the latter variety of commercialization, there is also a need for management assistance of the kind provided by the Illinois Technology Enterprise Corp. centers and the Oklahoma Technology Commercialization Corporation. Finally, both Ohio and Texas have found it necessary to clarify state law to ensure that commercialization activities are authorized to public institutions of higher education.

Table 11. Joint Research Initiatives in the Benchmark States/Regions

State/Region	Initiative	Life Science Focus	Agency/Total Budget	Comment
Maryland/ Statewide	Federal Lab Partnership Program	Part	Maryland Technology Development Corp.	Grants of $20,000 to $50,000 to encourage collaboration
Maryland/ College Park	Maryland Industrial Partnership Program	Part	University of Maryland Engineering Research Center/$2.1 million	Grants of up to $70,000 for two years, matched by partner
North Carolina/ Statewide	Collaborative Funding Assistance Grants	Whole	North Carolina Biotech Center/Kenan Institute	
North Carolina/ Research Triangle	Best practice research on tech transfer	Part	North Carolina Technological Development Authority/UNC System	Models successes at NC State
Ohio/Statewide	Biomedical Research and Technology Transfer Trust Fund	Whole	Board of Regents/Tobacco Settlement	A few large awards ($5 to $15 million) are contemplated
Oklahoma/ Statewide	Applied Research Support Program	Part	Oklahoma Center for Advancement of Science and Technology	Modest matching grants
Pennsylvania/ Philadelphia	Technology commercialization awards	Part	Ben Franklin Partners Center of Southeastern Pennsylvania	Repayable grants of up to $250,000 must involved industry partner
Pennsylvania/ State College	Challenge Investment Program	Part	Ben Franklin Partners Center of Central and Northern Pennsylvania	Repayable grants of up to $75,000 must be matched by industry partner
Pennsylvania/ State College	Challenge Investment Program	Part	Ben Franklin Partners Center of Central and Northern Pennsylvania	Repayable grants of up to $75,000 must be matched by industry partner
	Industrial Research Office	Part	Penn State	National model for industrial liaison office
Texas/Statewide	Technology Transfer and Development set aside in Advanced Technology Program	Part	Higher Education Coordinating Authority/$8 million	Requires 1:1 match by participating company

Table 12. Commercialization Initiatives in the Benchmark States/Regions

State/Region	Initiative	Life Science Focus	Agency/Total Budget	Comment
Illinois/Statewide	Illinois Technology Enterprise Corp. centers	Part	VentureTECH Initiative	Sites at Chicago and Urbana Champaign to assist technology entrepreneurs
Illinois/Chicago	ARCH (now being reorganized)	Part	University of Chicago	"Virtual venture" investing in start-ups to commercialize university technology
Maryland/ Statewide	University Technology Development Fund	Part	Maryland Technology Development Corp.	Grants up to $50,000 to universities for commercialization research
North Carolina/ Statewide	Proof of Principle Award Program	Whole	North Carolina Biotechnology Center	Grants up to $25,000 to universities for commercialization research
	Innovation Research Fund	Part	North Carolina Technological Development Authority	Up to $25,000 for companies commercializing technologies
North Carolina/ Research Triangle	Pilot projects in commercialization	Part	Kenan Institute/NC State	
Ohio/Statewide	Reform of Ohio code Section 3345.14	Part	Initiative led by Ohio State University	Delegates authority to oversee commercialization and conflict issues to institutions
Ohio/Cleveland	CCF Innovations	Whole	Cleveland Clinic Foundation	Reconstitution of tech transfer office and captive venture fund as one entity
Ohio/Columbus	OSU Technology Commercialization Company	Part	Subsidiary of Ohio State's Science and Technology Campus. Funded by Governor's Technology Action Fund	Pre-seed fund for commercialization research connected with OSU technology
Oklahoma/ Statewide	Oklahoma Technology Commercialization Corporation	Part	Nonprofit funded by Oklahoma Center for Advancement of Science and Technology	Intensive mentoring for technology entrepreneurs, including university spin-offs

Table 12. Commercialization Initiatives in the Benchmark States/Regions (continued)

State/Region	Initiative	Life Science Focus	Agency/Total Budget	Comment
Pennsylvania/ State College	Research Commercialization Office	Part	Penn State University	Works with tech transfer office to form start-up companies
Texas/Statewide	Clarification of Texas law	Part	SB 1190	Authorizes all institutions of higher ed to manager their commercialization processes
Texas/Houston	BCMT	Whole	For-profit subsidiary of Baylor College of Medicine	Makes pre-seed investments in formation of new start-ups to attract private capital
	Cancer Therapeutics Discovery Program	Whole	UT-M.D. Anderson Cancer Center	Commercialization research fund created by major donor

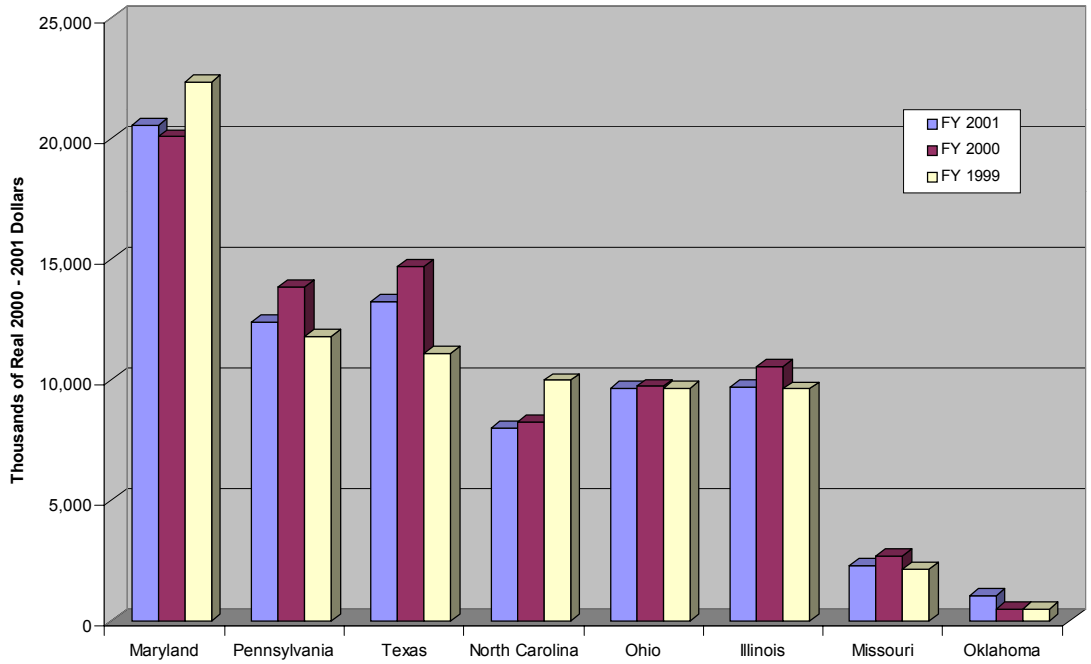
Risk Capital

Analysis

An important source of risk capital is the federal Small Business Innovation Research (SBIR)/ Small Business Technology Transfer (STTR) program. This program requires all federal agencies with annual extramural research and development budgets of more than $100 million to set aside 2.5 percent of those monies to competitively fund innovative research conducted by small businesses. Since it was initiated in 1982, the SBIR program has grown to become the single largest source of competitive early-stage research and technology development funding in the country for small businesses. Today, the SBIR program awards more than $1 billion annually. One way to gauge the level of bioscience research occurring in a state is to examine the number of NIH SBIR grants being awarded to a particular locality.

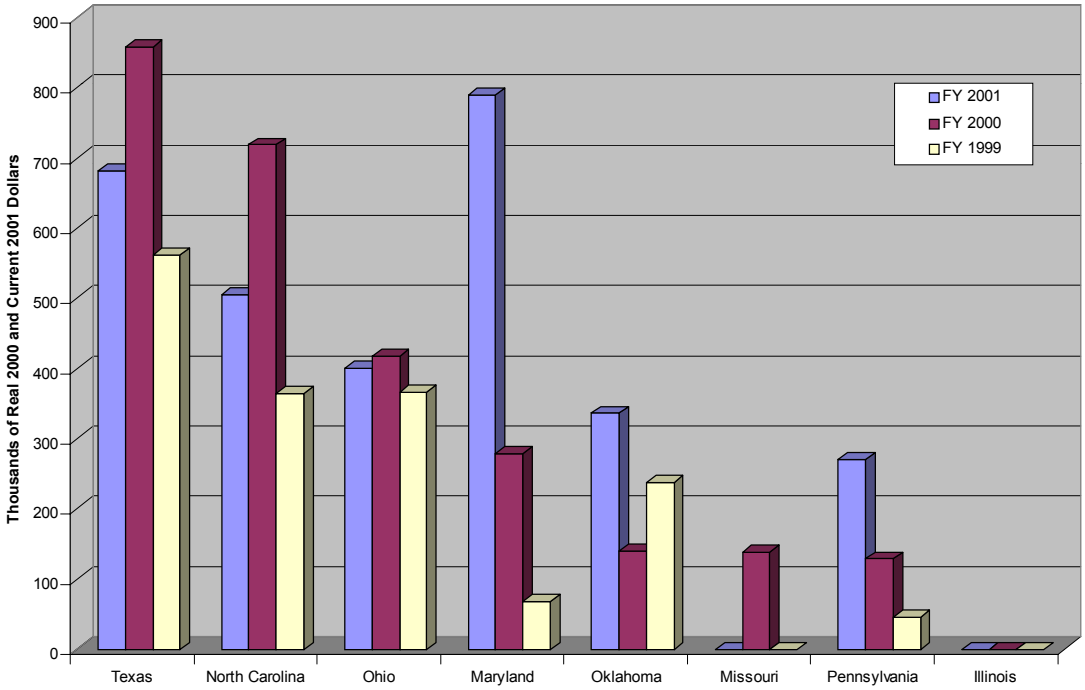
In dollar value of SBIR and STTR awards received from NIH in the last three reporting years (see Figure 12), Missouri ranks far behind all the benchmark states except Oklahoma. By contrast, some of the benchmark states are at or near the top of the national distribution. Maryland receives more than $20 million each year, exceeding Missouri's number by an order of magnitude. Looking also at SBIR awards from the U.S. Department of Agriculture as a proxy for plant-science activity, Figure 13 shows that Missouri surpassed only Pennsylvania and Illinois in FY 2000 and registered no success at all in FY 2001. Generally speaking, a downward trend occurred in all the benchmark states, but variability occurred from a higher base in more than half the set.

Figure 12. National Institutes of Health Phases I and II SBIR and STTR Awards



Source: National Institutes of Health.

Figure 13. Department of Agriculture SBIR Awards



Source: United States Department of Agriculture.

Initiatives

Reliance on the private venture capital marketplace to finance the earliest stages of *any* technology venture is now widely understood to be a barrier to building a critical mass of firms in a region or state that can lead to missed business opportunities. The scale requirements of the venture capital business and the risk/return preferences of its institutional investors preclude the kind of intensive due-diligence and ongoing involvement that is necessary for successful seed-stage investing. Today's funds are too large to do small deals, and staffing is not usually sufficient to handle small investments. These difficulties are amplified in the bioscience sector, where ventures often must survive (and finance) a long and grueling sequence of preclinical and clinical testing before any product can generate revenue.

States use a variety of strategies to increase the availability of pre-seed/seed stage risk capital. Approaches include

- **Encouraging locally managed private venture funds**—Some states have intervened in the private venture-capital marketplace to encourage the creation of locally managed firms, or at least offices of major national firms. Maryland's Venture Capital Trust, for example, is a "fund of funds" that allows state and City of Baltimore pension funds to invest in a diversified pool of professionally managed venture funds whose members have agreed to open Maryland offices (so-called "side-car" agreements specified targets but not requirements for local investment). Oklahoma's Capital Investment Board represents a similar pooled approach. In addition, both Pennsylvania and Ohio's public pension funds have for many years bought limited partnership interests in venture funds that are managed and invested in-state. Such programs can improve the investment environment for firms that face barriers because so little institutional capital is being managed locally, but they do not in and of themselves cause venture funds to target either early-stage businesses or bioscience businesses. Indeed, where pension funds are involved, trustees will accept little in the way of increased risk when "conventional" venture capital already meets their needs.
- **Encouraging creation of privately managed early-stage funds—**Recognizing the limitations noted above, some states have used their investing power (or indirectly, the purchasing power of intermediaries they have created) to catalyze formation of locally managed funds that are fully committed to early-stage investment. Usually this involves relying not on a national base of institutional co-investors, but on a locally recruited base of wealthy individuals, foundations, university endowments, and major corporate citizens who are willing to make "dual test" investments seeking both financial return and civic benefit to the region. Initiatives in this category include North Carolina's Bioscience Investment Fund, which is substantially owned by the NCBC; North Carolina's Academy Centennial Fund, which is solely owned by the endowment foundations of NC State University; and the Early Stage Partners funds in both Cleveland and Philadelphia.
- **Investing in direct or indirect quasipublic seed funds—**The most aggressive strategy is to bypass market preferences and constraints by investing in seed-stage enterprises directly through a state agency or indirectly through a quasipublic authority or state-chartered nonprofit. Initiatives in this category include the investment programs run by the Illinois Development Finance Authority, the Maryland Department of Business and Economic Development, the North Carolina Technological Development Authority, and two funds to

be managed by the Texas Comptroller's office. In addition, the regional Ben Franklin Centers in Pennsylvania now function largely as indirect pre-seed funds. In all these cases, bioscience is just one of the fields entertained. In both Maryland, an initial flow of appropriations has been replaced by reinvestment of realized gains, predominantly from the IT sector. From time to time, this mechanism has been criticized because of the difficulty compensating investment managers based on performance and the potential for political interference. However, there has been no scandal in any of the benchmark states.

Table 13. Risk Capital Initiatives in the Benchmark States/Regions

State/Region	Initiative	Life Science Focus	Agency/Total Budget	Comment
Illinois/ Statewide	Technology Development Bridge	Part	Development Finance Authority. $15 million annually	$100,000 to $250,000 equity investments
	Technology Venture Investment Program	Part	State pension fiduciary. $50 million committed to local venture capital	
Illinois/ Chicago	Evanston Business Investment Corp.	Part	Affiliated with Northwestern Research Park	Seed-stage equity investments
Illinois/ Urbana-Champaign	Illinois Ventures LLC	Part	UI-UC	Seed-stage equity for commercialization of university technology. Terminated due to political problems
Maryland/ Statewide	Maryland Challenge Investment Fund	Part	Department of Business and Economic Development. $1 million annually	Repayable grants up to $50,000
	Maryland Enterprise Investment Fund.	Part	Same. $8 million annually	Equity investments up to $500,000
	Maryland Venture Capital Investment Trust	Part	$19 million in capital from state and city pension funds	Targeted to venture firms doing business in state
	MdBIO	Part	Financed by lease of state-funded bioprocessing facility	$100,000 to $200,000 awards to companies

Table 13. Risk Capital Initiatives in the Benchmark States/Regions (continued)

State/Region	Initiative	Life Science Focus	Agency/Total Budget	Comment
North Carolina/ Statewide	SBIR loans	Whole	North Carolina Biotechnology Center	$75,000 to $150,000 loans
	Commercialization loans	Whole	Same	$10,000 to $25,000 loans
	Bioscience Investment Fund	Whole	$26 million in capital, $10 million from the state, invested through NCBC	Early-stage equity investments
	First Flight Venture Fund	Part	Same	Seed stage venture fund
	Fund of Funds	Part	Same	
Ohio/Statewide	BioInvestment Fund	Whole	Edison Biotechnology Center	
	Pension funds	Part	Various fiduciaries	Long-time investment in Ohio-based venture funds
Ohio/Cleveland	Early Stage Partners	Part	Funded by Governor's Technology Action Fund and private investors	Early-stage equity investments
Oklahoma/ Statewide	SBIR Grants	Part	Oklahoma Center for Advancement of Science and Technology	Incentive and matching grants
	Technology Business Finance Program	Part	Same. Offered through Oklahoma Technology Commercialization Center. $1 million a year	Repayable grants. Feeds angel network
	Oklahoma Capital Investment Board	Part	OCIB	Fund of funds financed by tax credit guarantee
Pennsylvania/ Statewide	Pension funds	Part	Various fiduciaries	Long-time investment in venture funds active in state
	Early Stage Partners	Part	Managed by Safeguard Scientifics. Capitalized by state appropriations, pension funds and private investments	Early stage equity investments

Table 13. Risk Capital Initiatives in the Benchmark States/Regions (continued)

State/Region	Initiative	Life Science Focus	Agency/Total Budget	Comment
Pennsylvania/ Philadelphia	Innovation, Emerging, and Technology awards	Part	Ben Franklin Technology Partners of SE Pennsylvania	Up to $250,000 in repayable grants
	Innovation Philadelphia Corp.	Part	TBD	Equity investments TBD
North Carolina/ Research Triangle	Academy Centennial Fund	Part	NC State University	Targeted to spin-offs, R&D partners, and firms located on Centennial campus
Pennsylvania/ Pittsburgh	Prototype awards and equity investments	N	Ben Franklin/ Innovation Works	Prototype awards up to $100,000. Equity investments up to $500,000
Texas/Statewide	Product Development and Incubator Funds	N	Comptroller and board. $25 million and $5 million funds, respectively	
Texas/Regional	Texas Capital Network	N	IC2 at UT-Austin	Angel network affiliated with UT Austin incubator

Technology Infrastructure

Initiatives

Ensuring that the private marketplace offers the right amount and type of space suitable for the development and growth of bioscience firms has been a major challenge for emerging bioscience regions. No data are available to determine the square footage of wet-lab space available in different states; however, a survey of state government initiatives in biotechnology[3] found that

- Nine states have used traditional economic development programs to fund facilities for bio-science companies and two states have programs specifically targeted to assisting bioscience companies with facilities development.
- Nine states have research parks focused exclusively on bioscience companies.
- Fifteen states have publicly sponsored bioscience incubators.

Like the capital markets, the commercial real estate markets tend not to supply, of their own accord, what bioscience firms need to grow: namely, inexpensive, wet-lab-equipped space zoned for research and process scale-up but situated very close to the research institutions and their key faculty who may serve as consultants or advisors. Given the high capital costs involved in con-structing permitted laboratory space, candidate parcels are often considered to have some other higher and better use, judging by risk-adjusted expected returns. Almost any developer will

[3] *State Government Initiatives in Biotechnology 2001*, Battelle and the State Science and Technology Institute, September 2001.

eagerly build wet-lab space for a credit-worthy single tenant (assuming available land and zoning); but, barring the exceptional inward recruitment of a major biotech firm, this is not the issue facing most communities trying to build a bioscience cluster. Rather, the problem lies in financing incubator and multitenant space for tenants who are not credit-worthy and whose concepts have not been proved in the marketplace.

Each of the benchmark states, other than Maryland, has created one or more technology-oriented research parks (see Table 14). These parks sometimes, but not always, include a university-affiliated incubator, and almost always involve some kind of public subsidy, either capital (land, mortgage, building construction) or operating (cash flow from incubators, loan guarantees, commitments to surge-space rental, etc.). These research parks have been developed in a wide range of cities and suburbs. Maryland has no full-scale research parks, but has aggressively developed more than 50,000 square feet of wet-lab incubator space at each major university center. In addition, Maryland's Sunny Day Fund makes loans to bioscience firms to construct wet-lab space in leased facilities. These loans are secured by the tenant improvements. Such programs operate on the assumption that if the beneficiary tenant becomes financially troubled, then these key improvements can be made available to another, second wave of tenants once possession of the lease has been secured. In effect, it becomes part of the permanent infra-structure of the state whether or not the initial beneficiary of the program survives.

Table 14. Specialized Facilities in the Benchmark States/Regions

State/Region	Initiative	Life Science Focus	Agency/Total Budget	Comment
Illinois/Chicago	Chicago Technology Park (56 acres)	Whole	Illinois Medical District Commission	Complex combination of institutional, incubator, and commercial space
	Northwestern/ Evanston Research Park (24 acres)	Part	Northwestern University and City of Evanston	
	DuPage County Research Park	Part	Airport Authority and others	Partnership with FermiLab
Illinois/Urbana-Champaign	UI Research Park (South End)	Whole	University of Illinois	Builds on older but underutilized ag incubator
Maryland/ Statewide	GMP Bioprocessing Center (54,000 square feet)	Whole	University of Maryland Biotech Institute/$21 million in capital cost	Leased to private operator, providing cash for MdBIO program

Table 14. Specialized Facilities in the Benchmark States/Regions (continued)

State/Region	Initiative	Life Science Focus	Agency/Total Budget	Comment
Maryland/ Baltimore	Alpha Center incubator (25,000 square feet)	Whole	Johns Hopkins University	
	UMBC Technology Center and Incubator (160,000 square feet)	Part	University of Maryland/Baltimore County/$17 million from the state	Adjacent to planned research park
	Bard Life Science Center (wet-lab incubator)	Whole	Baltimore Development Corp.	
Maryland/ College Park	Bioprocess Scale Up Facility and Technology Advancement Program (incubator)	Whole	University of Maryland Engineering Research Center/ $14 million in capital from state	
Maryland/ Rockville	Technology Development Center (wet-lab incubator)	Whole	Maryland High Tech Council and others/ $5 million in capital from the state	Part of 288-acre Shady Grove campus featuring branches of Maryland and Hopkins
North Carolina/ Research Triangle	Research Triangle Park (15 million square feet)	Part	Research Triangle Foundation (state supported since 1956)	
	Centennial Campus (1,300 acres)	Part	NC State University/ $250 million in combined public/private investment to date	Mixed use, academic/ industrial research park
Ohio/Cleveland	BioEnterprise and Edison Technology Incubators (25,000 square feet)	Whole	Subsidiary of Case Western Reserve/ Edison Biotechnology Center	May form anchor of planned urban BioPark
Ohio/Cincinnati	BIO/START incubator	Whole	Nonprofit with support from universities, hospitals, and P&G	
Oklahoma/ Oklahoma City	Health Center Research Park (23.5 acres)	Whole	Medical Technology and Research Authority/Presbyterian Health Foundation	Adjacent to OU Medical Center
Pennsylvania/ Philadelphia	University City Science Center (2 million square feet)	Part	Consortially owned	Has recently added back incubation function

Table 14. Specialized Facilities in the Benchmark States/Regions (continued)

State/Region	Initiative	Life Science Focus	Agency/Total Budget	Comment
Pennsylvania/ Pittsburgh	Pittsburgh Technology Center	Part	Pittsburgh Urban Redevelopment Authority	Houses research units of CMU and Ben Franklin and other intermediaries
	South Side Works	Part	Same	Houses research units of Pitt and mixed use
Texas/Houston	Houston Technology Center	Part	Nonprofit	Downtown
	Texas Medical Center (700 acres)	Whole	Consortial	Clinical, research, and institutional uses
	Southeast Texas Biotechnology Research Park (planned for 64 acres)	Whole	Consortial/$20 million from state toward infrastructure	Planned for directly adjacent to Medical Center
Texas/ San Antonio	Technology Research Park (1,236 acres)	Whole	Nonprofit	Anchored by UT Institute for Biotechnology. Includes incubator

Incentives and Tax Policy

Initiatives

No state among the benchmarks has implemented tax incentives or regulatory reform aimed specifically or exclusively at the bioscience industry, but several have R&D tax credits, and others have determined that bioscience sectors are included among those targeted by initiatives aimed at R&D in general (see Table 15). Components found in some tax initiatives include

- Treatment of R&D equipment on a par with manufacturing equipment with respect to exemptions or abatements from sales or use tax on its purchase
- Treatment of R&D equipment on a par with manufacturing equipment with respect to exemptions or abatements from tax on its value as tangible business property (where such tax is levied on businesses)
- Tax credits for R&D expenditure—either incremental of a baseline or nonincremental—and carryforwards and/or sale of unused credits.

In addition, all research-oriented firms including bioscience tend to benefit from provisions that recognize net operating losses (NOLs), and the ability to carry forward and/or sell the same. Bioscience firms tend not to benefit highly from "job creation" credits, which were designed (as Virginia's Lee Program and many others) to encourage high-payroll manufacturing sites rather than businesses with small payroll but high intellectual capital. Bioscience firms may or may not benefit from discretionary relocation programs, depending on the orientation of political leadership.

Table 15. Tax Policies Enacted in the Benchmark States

State	Initiative	Comment
Illinois	R&D Tax Credit	
Maryland	Sunny Day Fund	Flexible funding overseen by legislative committee
	R&D Tax Credit	
	Job creation tax abatement in targeted areas	Applicable to R&D businesses
North Carolina	Lee Tax Credit	Job creation. Applicability to life science is controversial
	R&D Tax Credit	
Ohio	Technology Investment Tax Credit	Administered by Department of Development
	R&D Tax Credit	
Oklahoma	Tax Credits for venture capital investment	See description under Risk Capital
	Enterprise Zones	
Pennsylvania	R&D Tax Credit	
	Opportunity Zones	Philadelphia life-science incubator is located in one
Texas	R&D Tax Credit	
	Enterprise Zones	

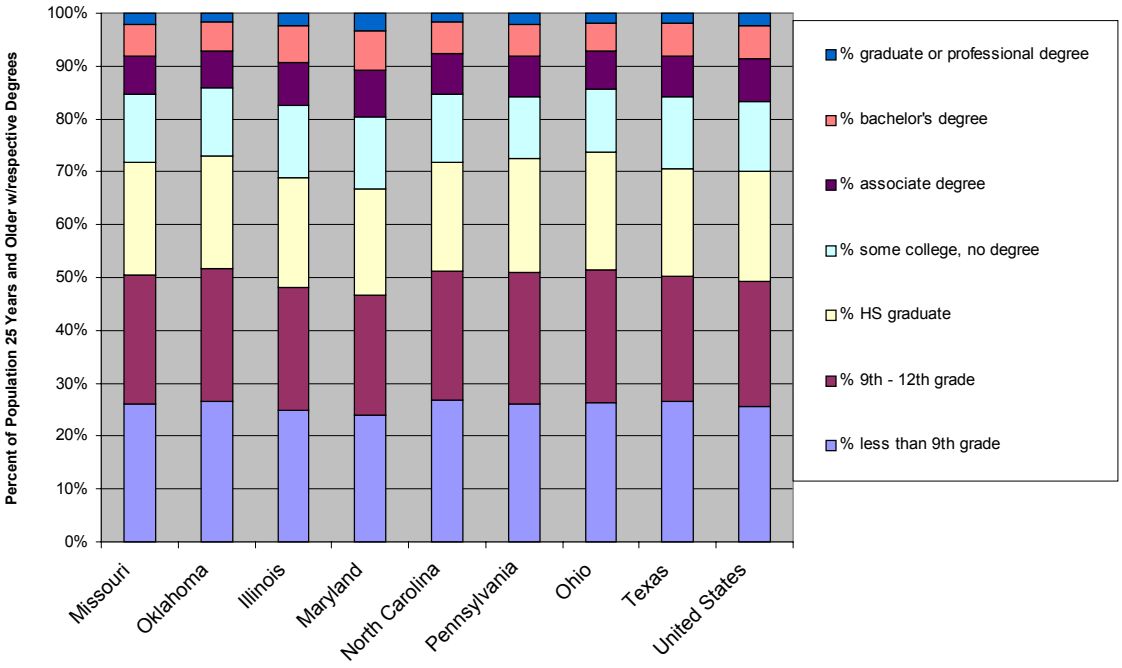
Workforce

Analysis

Census data show (see Figure 14) that, in educational attainment of the population over 25, Missouri is on par with most of the benchmark states in most categories. Only Illinois and Maryland have higher percentages of their workforce holding graduate and professional degrees, and Missouri has about the same as Pennsylvania in this category. However, considering all who hold a bachelor's degree or higher, the national average is slightly higher than that of Missouri.

Data from the National Center for Education Statistics (Table 16 and Figure 15) show that, during the most recent academic year, Missouri graduated 12,135 students in bioscience-related disciplines, with the vast majority of those in clinical fields. All the benchmark states produced more than half their bioscience-related graduates in the clinical subfield (including nursing), with Oklahoma the highest at 70 percent. Missouri had the second-highest number of total bioscience degrees per 100,000 capita, at 217 versus 227 for Pennsylvania. However, compared with the bioscience *workforces* in each state, Missouri produces fewer bioscience research graduates per existing bioscience job than all but two of the benchmark states. In the clinical and support sub-fields, Missouri bests both North Carolina and Maryland, suggesting a possible niche for the state.

Figure 14. Educational Attainment, 2000 Estimates



Source: United States Census Bureau, Census 2000 Supplemental Survey

Table 16. Bioscience Degrees, All Levels, 2000-2001 Academic Year

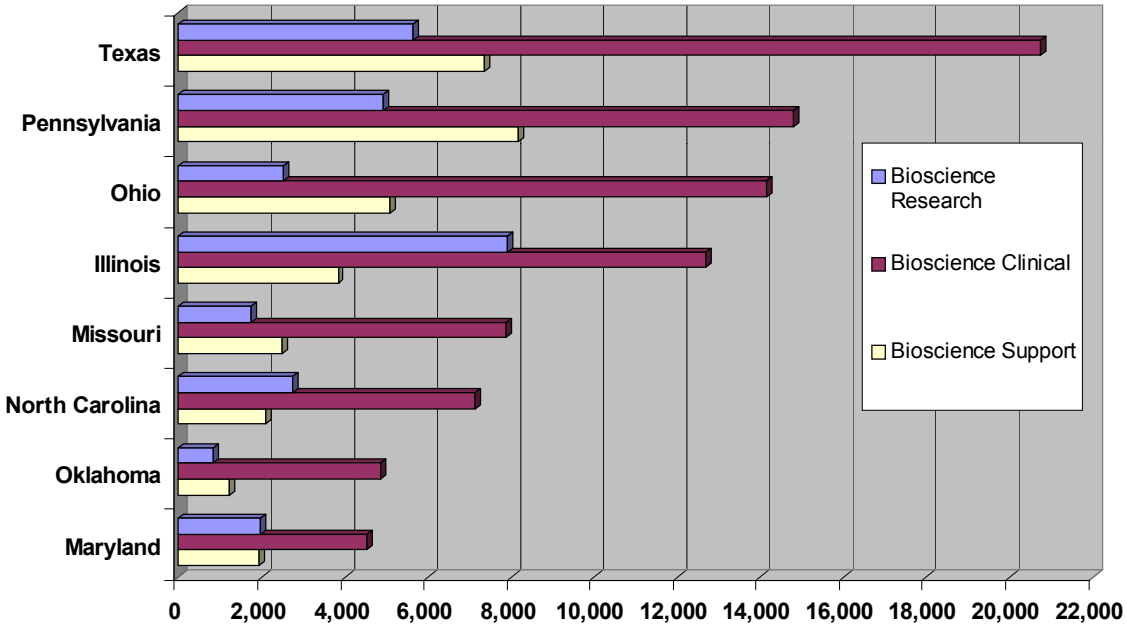
	Bioscience Research	Clinical	Bioscience Support	Bioscience Related Total	Degrees per 100,000 Capita		Degrees per 1,000 Bioscience Employment	
					Bioscience Research	Total	Bioscience Research	Total
Illinois	7,913	12,702	3,835	24,450	64	197	23.7	73.3
Maryland	1,969	4,542	1,930	8,441	37	159	15.3	65.4
Missouri	**1,742**	**7,893**	**2,500**	**12,135**	**31**	**217**	**10.2**	**71.2**
North Carolina	2,736	7,133	2,098	11,967	34	149	14.0	61.4
Ohio	2,514	14,138	5,085	21,737	22	191	8.4	72.4
Oklahoma	832	4,851	1,218	6,901	24	200	9.8	81.2
Pennsylvania	4,915	14,788	8,172	27,875	40	227	12.7	72.3
Texas	5,625	20,740	7,345	33,710	27	162	12.8	76.8

Note: Bioscience Research consists of research-oriented life science, medical, and agricultural fields; Bioscience Support fields complement bioscience, including computer science, chemistry, environmental studies, and zoology; Clinical fields are oriented toward medical and other professional practitioners.

Note: Because bioscience degrees are for each state proper, the employment used to calculate degrees per 1,000 bioscience employment for Missouri is for the state of Missouri only, without the metropolitan portions of St. Louis and Kansas City that are located in Illinois and Kansas.

Source: National Center for Education Statistics, COOL (College Opportunities On-Line) data; Dun & Bradstreet *MarketPlace* (employment level); United States Census Bureau (population); Battelle calculations.

Figure 15. Bioscience Degrees Awarded, All Levels



Source: National Center for Education Statistics.

Initiatives

As noted above, one beneficial side effect of any state-level R&D initiative is the creation of a local pool of highly trained professional bioscience talent. However, employers in the bioscience sector also need less-specialized labor, including college graduates who are well informed on bioscience issues but not themselves researchers, and associate-level or certificate-trained high school graduates who can fill laboratory technician roles. Of the benchmark states, several stand out as having created initiatives focused exclusively on filling the educational pipeline with students whose skills will be relevant to the bioscience sector (see Table 17).

For example, education and training have for many years been a fully recognized and funded program area of the NCBC, which has aggressively developed and promoted bioscience-friendly curricula at the secondary and postsecondary levels. In Maryland, while the state has not supported academic curricula (as it has in IT), there has been strong support for postsecondary technician training, resulting in creation of a specialty organization called the Biotechnical Institute of Maryland.

Another important workforce need, particularly for firms that are transitioning rapidly into production environments or that are recruited from other states, is the retraining of in-place workforce. Maryland now recognizes bioscience fields as one component among many in its programs for employer-customized training. In general, the community colleges situated in those communities, which already have a bioscience base, take the lead in providing services to this sector.

Table 17. Bioscience Workforce Initiatives in the Benchmark States/Regions

State/Region	Initiative	Life Science Focus	Agency/Funding	Comment
Illinois/ Statewide	Advanced technology training for liberal arts students	Part	Funded under VentureTECH	
Maryland/ Statewide	Science and Technology Scholarship	Part	Maryland Higher Education Commission. $4.5 million annually	
Maryland/ Montgomery County	A.A.S. Degree in Biotech Laboratory Technology	Whole	Montgomery County College	
Maryland/ Baltimore	Biotechnical Institute of Maryland	Whole	Self. Financed by Abell Foundation	Lab technician training
Oklahoma/ Statewide	Internship Program	Part	OCAST	For students and faculty at Oklahoma companies
Pennsylvania/ Statewide	SciTech Scholarships	Part	Higher Education Assistance Authority. $24 million annually	
Texas/ Statewide	Toward Excellence, Access and Success Program	Part	$20 million annually	

Finally, a critical need for the bioscience sector is entrepreneurial management talent. North Carolina addresses this need by providing mentoring service through the nonprofit Council for Entrepreneurial Development at Research Triangle, and the University of Maryland's Dingman Center for Entrepreneurship performs an analogous function in that state.

SUMMARY

Missouri's R&D base remains less developed than those of the benchmark states; however, it is growing faster than the majority of the benchmark states. In particular, Missouri is experiencing rapid growth in NIH funding. Missouri lags the benchmark states but is making progress in building the state's life science venture capital market.

The benchmarking analysis also shows that other states have been more aggressive in investing in R&D infrastructure, creating and supporting programs to encourage and facilitate technology transfer and commercialization, and providing assistance to new and expanding life science companies. To compete with the states seeking to become leading life science centers as well as with those that have established centers, Missouri will have to increase its commitment to investing in its research infrastructure and providing greater support for the establishment and growth of life science companies.

Appendix A:
Regional Life Science Profiles

Illinois (Chicago, Urbana-Champaign, and Peoria)

OVERVIEW

Although Chicago has long been a center of biomedical research and clinical excellence, the region's progress as a life-science industry center has been slow and uneven. In part this may owe to the "split" of university life-science assets between Chicago and the small "downstate" community of Urbana-Champaign, where the main campus of the University of Illinois is located (along with agricultural research). There is also a branch medical school in Peoria, in the central part of the state. UI has an ungainly organizational structure that has kept the various campuses from working together in any coherent way on R&D or technology-commercialization strategy, and which has starved them for resources for local development. The strongest life-science initiatives have been from two private universities—Northwestern, which operates a vigorous research park, and Chicago, which pioneered an innovative model for formation of spin-out companies from on-campus research. Until recently, the state government has applied no pressure for cooperation or even vigorous local action.

The State of Illinois was an early participant in the 1980s wave of state-level agencies for technology-led economic development, but a later governor dismantled the centralized office. While several state agencies still administer programs of importance to the life-science sector, coordination has until recently been left to the private sector, in the form of the Illinois Coalition[1], a statewide public-private partnership that is based in Chicago. It was the Coalition that first developed a cluster-based economic-development strategy for the state, and offered its services as a "gateway" to various state programs, including an innovative early-stage finance fund operated by an otherwise fairly conventional state financing authority. The Coalition also spurred the formation of a technology strategy by Mayor Daley of Chicago. That city-level strategy in turn reawakened the governor and the Legislature to the need for concerted action at the state level. Governor Ryan responded to that call by creation of a "VentureTECH" budgetary initiative coordinated from his office. This initiative will result in significant new "bricks and mortar" investments in both Chicago and Urbana-Champaign; but, more importantly, it has raised the expectations of commercial outcomes from the public-university system.

STRATEGY OVERVIEW AND DIRECTION

Statewide

VentureTECH is described as a "strategic technology investment initiative" that is driven from the Governor's office.[2] It is characterized as being worth $1.9 billion; but, this amount is cumulative over several years and represents many different kinds of expenditures and investments through a diversity of agencies, state authorities, and nonprofits. In reality, VentureTECH is less a coherent strategy than a funding umbrella, and its elements are described in the following appropriate categories. Included in VentureTECH is creation of an Illinois

[1] See http://www.ilcoalition.org/ichome.htm.
[2] See http://www.state.il.us.tech/venture.htm.

Office of Technology, joined to a reorganized Illinois Science and Technology Advisory Committee and a newly formed Illinois Biotechnology Advisory Committee.[3] To some degree the life-science efforts draw on a strategy conducted in 1997 for the state Department of Commerce and Community Affairs (DCCA).[4]

Lacking a single agency, the state as a practical matter still delegates much of the strategy "steering" function of the Illinois Coalition. The Coalition has long recognized biomedical and environmental technology as two of the key cluster areas in which the state has a strategic interest.

Regional

Chicago Metropolis: 2020[5], a regional planning exercise conducted by the Commercial Club, calls for leadership to "enhance the region as a high technology center," but focuses mainly on broader issues of land use, taxation, transportation, and public education. A tighter focus on technology-based economic development can be found in Mayor Daley's "New Economy Growth Strategy for Chicagoland."[6] The strategy recognizes the same clusters identified by the Illinois Coalition (including biomedical) and near-term actions grouped under three strategic goals.

- **Increase angel and seed-capital funding**
    - Create new seed funds, with state and city backing
    - Facilitate creation of angel networks by reaching out to wealthy individuals and linking them with new-business ideas inside the City
    - Recruit leading firms in early-stage funding to open offices in the Chicagoland area.
- **Raise the rate of technology transfer from R&D centers**
    - Work with the state and federal governments to increase R&D funding levels, citing the California Institutes as an example
    - Assist universities other than Chicago (which is already well advanced) in identifying and removing barriers to commercialization
    - Solicit funding from public and private sources to upgrade facilities and fund chairs for recruitment of eminent scholars.
- **Create a more connected, vibrant entrepreneurial community**
    - Develop geographic concentrations of high-tech activity
    - Expand existing programs for entrepreneurs
    - Build a support network to professional-service providers.

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[3] For all three, see http://www.commerce.state.il.us/technology/Tech_Resource.htm.

[4] See "Illinois State Strategic Plan for the Biotechnology Industry: Phase I Report." Chicago: Centromere Group, December 1997.

[5] See http://www.chicagometropolis2020.org/

[6] "A New Economy Growth Strategy for Chicagoland: A Partnership for Action." Available at: http://www.chicagotechnologytoday.com.

City strategy is steered by the Chicago Council of Technology Advisors, an ad hoc group convened by the Office of the Mayor.

Recently Peoria—home to a branch of the University of Illinois College of Medicine—prepared its own life-science strategy.[7] Principal elements of the strategy and short- to mid-term action items are

- **Strengthen the region's R&D base** in identified core areas, by collaboration among key anchors (the College, Bradley University, the USDA Center for Agricultural Utilization Research, and several hospitals and hospital systems)
- **Build the region's technology infrastructure** to nurture a critical mass of bioscience industries
- **Create an entrepreneurial culture** by forming home-grown businesses in the biosciences
- **Establish a regional business climate** supportive of the bioscience effort
- **Mobilize community and regional support.**

R&D BASE

The R&D base in Illinois includes the universities already mentioned as well as two important Department of Energy laboratories sited in the Chicago region: Argonne[8] and Fermi.[9] Since 1989 both public and private universities and their partners in the federal labs have leveraged an Illinois Technology Challenge Grant program operated by the DCCA. Despite is name, however, this program is not a conventional university/industry challenge grant. Rather, it is a flexible "opportunity" fund for projects that will leverage substantial federal or private research funding. Eligible applicants include universities; federal labs; nonprofit research institutes; partnerships between two or more private firms; industry associations; and any combination of private firms, universities, and nonprofit research institutes. In 2001 the program funded 18 projects for a total of $4.2 million.

On top of the Challenge Grant, VentureTECH specifies additional investments in the same spirit:

- **Centers for Academic Excellence**—funding for teaching hospitals to conduct additional clinical research and develop new therapies, leveraging federal grants
- **Newly constructed "bricks and mortar**," including
    - Post-Genomics Institute at University of Illinois/Urbana-Champaign ($80 million)
    - Medical School ($93 million), Chemical Sciences ($71 million), and Pharmacy ($53 million) buildings at UIC, and Biomedical Research Building at Northwestern ($30 million)
    - Chicago Technology Park Expansion (see "Technology Infrastructure")
    - Chemical Sciences Building and Pharmacy Buildings at UIC

[7] See "A Regional Bioscience Strategy for Central Illinois." Draft. September 2001.
[8] See http://www.anl.gov/.
[9] See http://www.fnal.gov/.

- **Technology Advancement Funding** from the Department of Commerce and Community Affairs to help businesses and research institutions develop advanced technologies and leverage federal funds.

KNOWLEDGE TRANSFER

The Illinois Coalition operates a technology resource center designed to link industry and research institutions, including a program to promote SBIRs. Pertinent elements of the VentureTECH initiative include

- **Illinois Technology Enterprise Corporation**, a network of regional commercialization centers, the first two of which are at Urbana-Champaign and Northwestern University. A third is planned for a research park at Du Page County Airport, involving Fermilab, where Battelle operates a field office for a NASA-funded technology transfer center.
- Expanded support for the **University of Illinois** Office of Technology Transfer and for a new Technology Incubator.

TECHNOLOGY COMMERCIALIZATION

An innovative commercialization model that developed in the Chicago region is the ARCH Development Corporation (ADC), a nonprofit created to serve as technology-transfer agent for Argonne National Laboratory and the University of Chicago. ADC is being reconstituted as an operation internal to the University of Chicago,[10] but its history is worth recounting. In addition to its duties negotiating patent licenses, ADC developed an innovative "virtual venture" model for spin-out of start-up companies based on Chicago properties. Using surpluses it had "banked" in University of Chicago accounts thanks to early licensing and spin-out successes, ADC was able to finance the formation of new entities designed to take IP into the marketplace. ADC paid for formation of the legal entities; provided them with shared business services; recruited executive talent who serve for equity interest; and actually invested pre-invested pre-seed amounts in these in concert with the Illinois Development Finance Authority's Technology Development Bridge Fund (see "Risk Capital"). It is not clear whether these activities will survive under the new organization. However, ADC has spun out two generations of venture capital firms: ARCH Development Partners, a conventional firm with strategic relationships with many university campuses nationwide, and ARCH Development Fund, a seed-stage fund serving the Midwest that competes with a similar one offered by CID Equity Partners. These two funds and their general partners have no formal or financial connection with ADC or its successor.

RISK CAPITAL

Statewide

The Illinois Coalition operates as a gatekeeper for the Illinois Development Financing Authority, which offers an innovative program known as the Technology Development Bridge.[11] The Bridge makes first-round equity investment of $100,000 to $250,000 on terms identical to the

[10] See http://www-arch.uchicago.edu/
[11] See http://www.ilcoalition.org/tdbinfo.htm.

(required) participation by other early-stage or angel investors from the private sector. Under VentureTECH, this program will increase by $15 million a year over the next three years, resulting in a 50 percent increase in capital committed.

In addition, under the VentureTECH initiative, the State Treasurer as fiduciary for the pension funds will invest up to 1 percent of assets, or $50 million, in an Illinois Technology Venture Investment Program targeting venture funds with a declared interest in Illinois deals. In addition, staff of all investee pension funds—whether or not they are in this program—will be expected to at least consider deals forwarded to them by the DCCA.

Regional

A notable initiative in the Chicago region is the Evanston Business Investment Corporation (EBIC), which provides seed capital and microloans. The incubator is governed by a separate six-member board of directors including a venture capitalist, an assistant city manager, a patent attorney, two bank officers, and a representative of the research park. EBIC was organized in 1986 as early-stage fund. Its $1 million capitalization was raised by Evanston Inventure, a local economic-development partnership. Investors included the university, two banks, an insurance company, and the American Hospital Supply Corporation. EBIC invested in 23 start-ups between 1986 and 1992, all located in Evanston. It returned more than $2 million to investors. In 1993 EBIC organized a second fund, Evanston-Northwestern University Partners LP, which now manages $1.5 million and has expanded to include investee companies throughout the Chicago metropolitan region, although special emphasis is placed on firms located in Evanston and/or affiliated with the university.

In Urbana-Champaign, two attempts to create venture-capital funds specifically focused on spin-outs from UIUC have been unsuccessful. The latest, Illinois Ventures LLC, was closed in July. The university would have been a general partner and provided operating support, but would have raised investment funds from outside limited partners committed to the mission. Political issues derailed the initiative, as had been the case the last time this was tried in the mid-1990s.

TECHNOLOGY INFRASTRUCTURE

Regional

Chicago Technology Park[12] is a planned 56-acre biotechnology park that is one component of a comprehensive urban redevelopment project, a 560-acre Illinois Medical District (IMD)[13] lying along the East-West Expressway. IMD is both a geographic district and an organizational entity charged with its stewardship. IMD as an organization is governed by a seven-member board representing its "members," including hospitals, universities, county agencies, the state, and the city. The IMD Commission is charged with coordinating not only real-estate development and technology projects, but also security, transportation, and other redevelopment issues. The IMD as a geographic entity is divided in three main parts:

[12] See http://www.uic.edu/depts/ovcr/ctp/intro.html.
[13] See http://www.imdc.org.

- A large institutional core to which is attributed more than $200 million in research spending, 5 million patient visits annually, and $5 billion in "economic impact"
- The 56-acre Chicago Technology Park, which so far features the Chicago Technology Park Research Center, a three-story, 56,000 square-foot, 24-hour incubator constructed in 1987 for biotech firms
- The Chicago Technology Campus[14], a 17-acre parcel prepared for development by private investors of more than 1 million square feet of research, biomedical and/or commercial properties.

Northwestern/Evanston Research Park[15] is a 25-year-old initiative building on a 24-acre site adjacent to downtown and comprising parcels variously owned by Northwestern University and the City of Evanston. The park was a follow-on to an economic-revitalization initiative that began in 1983 with creation of Evanston Inventure, a local economic development partnership that spun off a seed fund with private investors. Of 18 planned sites, four have been developed, and the 315,000 square feet in service are 97 percent occupied. Some 89 organizations (including a university biomedical research institute and several large life-science companies) employ more than 850 persons. Current facilities include two business incubators and two wet-lab-equipped multitenant buildings. The park is conceived as a joint venture of Northwestern University and the City of Evanston.

In exurban Du Page County, a research park is being created on land adjacent to Fermilab. It will probably not have a heavy life-science component. Unlike Argonne, a multipurpose lab that has been heavily involved in technology spin-outs, Fermi is a special purpose lab dedicated to operation of a particle accelerator. As a result, the park has looked for its anchor and leadership not only to Fermi but also to a broad array of other actors. Its progress is still early stage.

In Urbana-Champaign, UI is concurrently developing two research parks. The one on the northern end of the campus is IT oriented.[16] The one on the south end will be focused on the life sciences. This latter park will leverage an incubator that has been operated for about a decade as a unit of the College of Agricultural, Consumer and Environmental Sciences. (However, that original structure was designed with inadequate infrastructure for advanced agricultural research, and so it has been occupied to date mainly by engineering-oriented companies.) A new building of 25,000 square feet is planned.

TECHNOLOGY INCENTIVES

Illinois offers an R&D tax credit.

WORKFORCE

Under VentureTECH, the state is supporting advanced technology training for workers whose primary educational background is in the liberal arts.

[14] See http://www.usequities.com/CTC/CTC.htm
[15] See www.researchpark.com/.
[16] See summary at http://www.cs.uiuc.edu/whatsnews/newsletter/summer00/researchparks.html.

SUMMARY OF KEY FACTORS

- **Private-sector leadership**—The Illinois Coalition has been most effective in picking up the slack created by the state's earlier withdrawal from technology-led economic development, cooperating with key agencies that continued to fund important programs.
- **Aggressive local strategy in Chicago—**There can be little doubt that Chicago's aggressive efforts to create its own technology strategy at the city level have inspired the state government to respond with its own package of investments and new expectations of coordination and cooperation from UI.

Maryland (Baltimore and Suburban Washington)

OVERVIEW

Maryland now boasts two metropolitan regions showing strength in life-science business development: Baltimore City, home to Johns Hopkins University and the University of Maryland Medical School; and the ring of suburbs stretching clockwise around Washington DC, featuring a dense cluster of federal laboratories near Rockville and the main campus of the University of Maryland in College Park.[17] However, this success did not come quickly. For many years, the region was characterized by small, stable firms in service relationships with large federal laboratories such as the NIH campus in Bethesda[18], the National Institute of Standards and Technology in Gaithersburg[19], the Agricultural Research Service in Beltsville[20], and diverse facilities of the FDA[21] around the region.

In an attempt to generate a cluster of rapidly growing bioscience firms that face consumer and industrial markets, Maryland has supported advanced life-science research since 1985. That year the state created the University of Maryland Biotechnology Institute[22], an independent affiliate of the University of Maryland System. Subsequently, the state built facilities for UMBI in Baltimore, College Park, and Rockville—and then funded core research intended to attract additional, merit-based federal funding. However, this approach by itself achieved very little success. In 1991 the State of Maryland committed to an industry-led Commercial Biotechnology Strategy that deepened the strategy considerably, and seems to have played a major role in transforming the sector.

Now, some of the nation's most prominent and fastest-growing biotechnology firms can be found in this same corridor, in complex relationships (part competitive, part collaborative) with the same federal laboratories. The most intense business formation has taken place in the I-270 corridor Northwest of DC, and especially in Rockville, where Montgomery County created an industrial park specifically targeted at life-science businesses. The state also invested heavily in wet-lab incubator capacity and seed-capital funds. Now, in Montgomery County alone (as reckoned by the planning board last year)[23] there are 12 publicly traded life science companies, with combined market cap of $23 billion, and a host of private firms. Among the well-known names are Human Genome Sciences; Celera Genomics; Medimmune; Gene Logic; and TIGR—The Institute of Genomic Research. Already several of these have spawned a second wave of entrepreneurial start-ups. Baltimore also has generated a smaller but still significant pool of life-science start-ups and public companies.

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17 Technically, the Washington region includes counties in northern Virginia and West Virginia, but these are excluded from consideration because their development is IT-oriented, and this report is focused on implications for the policy at the level of one state government.

18 For a sense of the magnitude of this campus, see the maps at http://www.nih.gov/about/.

19 Again, a look at the map is instructive: http://www.nist.gov/public_affairs/maps/nistgbrg.htm

20 For a history and summary of what is Beltsville, see http://www.ba.ars.usda.gov/history/

21 For a recent groundbreaking, see http://www.choosemaryland.org/pressroom/speeches/fda.asp.

22 See http://www.umbi.umd.edu/.

23 See "Technical Report: Biotechnology Industry in Montgomery County: A Study of the Factors Contributing to the Development of the Industry and Related Real Estate Issues." Rockville, Montgomery County Planning Board, 2000. Available: http://www.mc-mncppc.org/factmap/biotech/biotech_toc.htm.

STRATEGY OWNERSHIP AND DIRECTION

Statewide

All together Maryland spends about $50 million annually on technology development (not only the life sciences but dispersed among 20 programs managed by 10 different agencies). Responsibility for strategy formation and execution is shared mainly by two public agencies:

- The cabinet-level Maryland Department of Business and Economic Development[24], a conventional commerce agency that had initial custody of the Commercial Biotechnology Strategy and operates several highly innovative financing programs aimed at early-stage technology ventures and technology infrastructure
- The Maryland Technology Development Corporation[25], a state coordinating agency created in 1998 and funded initially with proceeds of the Enterprise Fund (see "Risk Capital"). It also operates certain programs aimed at fostering business incubation and partnerships between technology companies and the university and federal laboratory sectors.

Regional

In both metropolitan regions, the principal strategy driver is a technology council. Serving mainly the DC suburbs (although its current mandate is statewide) is the Tech Council of Maryland[26], formerly the Montgomery County High Technology Council. The Montgomery County Planning Board, as noted above, plays an analytical role.

In Baltimore City, with the financial assistance of the local Abell Foundation, the Greater Baltimore Committee spun off a Greater Baltimore Technology Council[27], which has been active in Mayor O'Malley's "Digital Harbor" downtown renewal strategy, and also in life-science promotion. The Baltimore Development Corporation has helped develop and now manages several business incubators.

R&D BASE

Statewide (Distributed Across Both Metropolitan Regions)

Aside from the research giant Johns Hopkins and the UM Medical School in Baltimore, and UM College Park in suburban Washington, the state's other principal research asset is UMBI itself. Elements of the UMBI complex include:

- **The Center for Agricultural Biotechnology (CAB)[28],** located in 20,000 square feet of the University of Maryland Plant Sciences Building at College Park. Thrust areas include plant/pathogen interactions, genome manipulation of insects of agricultural and medical importance, poultry viruses and vaccines, and bioprocess engineering using microbial and insect-cell systems and enzymatic strategies for waste minimization.

[24] See http://www.choosemaryland.org/whoweare/divisions/index.asp.
[25] See http://www.marylandtedco.org/.
[26] See http://www.mdhitech.org/.
[27] See http://www.gbtechcouncil.org/.
[28] See http://www.umbi.umd.edu/~cab/.

- **The Center of Marine Biotechnology (CMB)**[29]**,** a $160 million, 260,000-square-foot research facility based at the Baltimore Inner Harbor, where a K-12 educational facility it once operated jointly with the nearby National Aquarium has foundered and may be turned into a life-science incubator.
- **The Center for Advanced Research in Biotechnology (CARB)**[30]**,** an 85,000-square-foot facility at the Shady Grove satellite campus of the University of Maryland, which collaborates on protein structure with nearby NIST. With 130 scientists (17 PIs) , CARB focuses on advanced studies of protein via crystallographic, NMR, and computational studies conducted in collaboration with scientists at nearby NIST. CARB is planning a $38 million, 140,000-square-foot CARB II, focusing on commercial applications in drug design, genome analysis, and biological manufacturing. Some of the new space also will be used by CAB.
- **The Medical Biotechnology Center**[31]**,** a 196,000-square-foot basic molecular science laboratory in downtown Baltimore on the campus of the University of Maryland Medical School. The center also included the virology labs of Dr. Robert Gallo, formerly of NIH.

Despite this array of investments, cumulating to $61 million in capital, insufficient cooperation is widely conceded among UMBI and other components of the UM system.

KNOWLEDGE TRANSFER

Statewide

TEDCO operates a Federal Laboratory Partnership Program.[32] This program makes matching grants of up to $20,000 to offset the costs of joint ventures between Maryland companies and federal laboratories, or grants of up to $50,000 for demonstration projects, repayable up to three times the original investment. It is unclear to what extent this program can be credited with the recent increase in the number of Cooperative Research and Development Agreements (CRADAs) between Maryland companies and the federal laboratory complex near Washington, but it is certainly intended to capitalize further on past success.

Regional

At UM College Park, the Engineering Research Center operates a range of programs, including the Maryland Industrial Partnership (MIP) Program.[33] MIP offers matching grants of about $70,000 per year for up to two years to support R&D projects conducted by Maryland companies in collaboration with the Engineering Research Center. These funds have supported about 100 life-science projects over the 1990s, usually at the interface with chemical engineering. MIPS-funded life-science projects often leverage the state-funded BioProcess Scale-Up Facility (see "Technology Infrastructure"). Any company participating in a MIPS project must make a cash contribution, have Maryland operations, and submit a business plan summary for commercialization of the research. The current state appropriation for MIP is $2.3 million,

[29] See http://www.umbi.umd.edu/~comb/.
[30] See http://www.cstl.nist.gov/div831/carb/carb.html.
[31] See http://www.umbi.umd.edu/~mbc/.
[32] See http://www.marylandtedco.org/programs/federal_labs.html.
[33] See http://www.erc.umd.edu/MIPS/

exclusive of a $450,000 appropriation for the umbrella Technology Initiatives program at the Engineering Research Center.

TECHNOLOGY COMMERCIALIZATION

Statewide

TEDCO also offers a University Technology Development Fund.[34] Awards of up to $50,000 are made to universities for proposals that address the most significant hurdles to commercialization.

RISK CAPITAL

Statewide

Some of the most intense program development in Maryland has occurred in the area of early-stage risk capital for technology firms. The principal sources of risk capital open statewide to life-science firms include

- **The Challenge Investment Fund and Enterprise Investment Fund** operated by DBED.[35] The Challenge Fund offers technology firms repayable grants of up to $50,000, and the Enterprise Fund makes equity investments of up to $500,000 when matched by private-sector investors. Both make life-science investments, probably in the range of 40 percent of their activity. Since FY 1993, the state has invested $4.35 million in the Challenge Fund, and $11 million in the Enterprise Fund. Current appropriations are $1 million and $8 million, respectively. Public offerings of portfolio companies of the Enterprise Fund (including IT investments and dot-coms that were cashed out at the right time) have returned to the state $45 million that is being reinvested in several programs, including
    - TEDCO itself
    - The Enterprise Venture Capital Limited Partnership, a fund of funds in which DBED holds limited-partnership interests for the state
    - Maryland Technology Commercialization Fund, an SBIC managed by Toucan Capital of Bethesda[36], with a $4 million limited-partnership investment by DBED.
- **The Maryland Venture Capital Investment Trust**[37], a $19 million "fund of funds" operated by the state Investment Financing Group. The Trust state and City of Baltimore pension funds co-invest with other return-motivated entities around the nation in (currently eight) privately managed venture partnerships that agree to open a Maryland office. State officials believe the program has brought so much new outside capital to the region that the portion of the overall pool invested in Maryland firms exceeds the state's investment in the Trust by a ratio of 20:1. Again, the focus is not exclusively life-science, but one of the earlier

[34] See http://www.marylandtedco.org/programs/UTDF.html.
[35] See http://www.dbed.state.md.us/finance/ifg.htm.
[36] See http://www.toucancapital.com/about.htm
[37] See http://www.mdarchives.state.md.us/msa/mdmanual/25ind/html/76vent.html.

investments was in Oxford Bioscience Partners[38], which has done several large deals in the Rockville/Gaithersburg corridor.

- **MdBIO[39]** (a nonprofit agency, but see "Technology Infrastructure" for information on how its financing ultimately stems from the state) supports projects of between $100,000 and $200,000. MdBIO support is usually targeted to equipment or R&D needed by a Maryland life-science company to develop a new product or service. Categories eligible for support are: GMP manufacturing (up to $200,000); product development (up to $100,000); biomanufacturing (up to $100,000); and business development (up to $50,000).
- **Maryland Health Care Product Development Corporation,** intended to provide funding for commercialization and proof of concept but now acting more like a health-care venture capitalist. The state last supported the Alliance in FY 1994 with $350,000. Its capital is currently $5.5 million.
- **The Dingman Center for Entrepreneurship**[40] at UM has been active in creating a Baltimore-Washington Venture Group/Private Investors Network.

Regional

Baltimore has an extensive banking and insurance sector, which supports nationally recognized venture-capital firms such as New Enterprise Associates and the venture division of Alex. Brown. However, the region came to realize that much of the capital these firms manage was being exported, particularly to California. In response, The Abell Foundation[41] of Baltimore has created a unique "internal venture fund" that is investing up to $30 million of Abell's endowment in private equity issued by companies providing employment opportunity in the City of Baltimore. While some of these deals have been in low-tech firms, and most of the high-tech deals have been in information technology, one of Abell's early successes was Guilford Pharmaceuticals, a spin-off from another biotech company.

In the DC suburbs, the state is considering working with Bethesda-based Emerging Technology Partners[42] to create a state-sponsored venture fund focused on biotech.

TECHNOLOGY INFRASTRUCTURE

Statewide (And Distributed Across the Regions)

Key technology infrastructure includes two pilot plants, one in each region:

- The $21 million, 54,000-square-feet **GMP-certified Maryland Bioprocessing Center,** which was subsequently leased to Bio Science Contract Production Corp., a 100-employee private, for-profit operator, with proceeds supporting a cluster-development organization called MdBIO.[43]

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38 See http://www.oxbio.com/index.html.
39 See http://www.mdbio.org/newsite/about/index.html.
40 See http://www.rhsmith.umd.edu/dingman/docs/about/index.htm.
41 See http://www.abell.org.
42 See http://www.emrgtech.com/about.htm
43 See background at http://www.mdbio.org/newsite/about/.

- In College Park, a **Non-GMP Bioprocess Scale-Up Facility** aimed at earlier-stage scale-up investigations, operated by the Engineering Research Center of the University of Maryland. It claims use by more than 30 firms annually.

In addition, TEDCO is supporting and vigorously promoting a network of wet-lab incubators that crosses both regions:

- **The Technology Development Center,** featuring 24 modular wet labs. The TDC is part of the 288-acre Rockville/Shady Grove complex that includes CARB and satellite campuses of both the University of Maryland and Johns Hopkins University. Cumulative capital investment by the state is nearly $5 million.
- **The Technology Advancement Program**[44], an incubator based at the Engineering Research Center at UM-College Park. The current state appropriation is $248,000. Cumulative capital investment by the state is $14 million.
- **The Alpha Center**, a 25,000 square-foot incubator at the 130-acre Bayview Campus, a research park created by Johns Hopkins University on the campus of a former Baltimore City municipal hospital. Bayview also features a 100,000 square-foot multitenant facility occupied by academic departments, government agencies, and private-sector firms.
- **The UMBC Technology Center and Incubator**[45]**,** a huge (160,000-square-foot) incubator created at the University of Maryland Baltimore County (south of the city), from space surplused by Lockheed Martin. It is adjacent to a planned Research Park on the UMBC campus itself, sited very close to the I-95 corridor and the Amtrak rail station serving BWI Airport. Cumulative capital investment by the state is $17 million.
- **The Bard Life Sciences Center,** formerly run by Baltimore City Community College and now managed by the Baltimore Development Corporation[46], the nonprofit agency that serves as the city's economic-development arm.

Maryland Economic Development Corporation (MEDCO), an affiliate of DBED, acted as developer of both the Technology Development Center incubator and the UMBC Tech Center.

Independent of state initiative, the Johns Hopkins University has created a research park not in its own region but in Montgomery County, where it had acquired a 138-acre farm in 1989 at a below-market price from an owner interested in preserving low-density development.[47] In 1997 the university announced that it would convert the farm to a university-related research park. The first 30 acres are under development in partnership with a private developer. Consideration is now under way in the legislature for a proposed allocation of $150 million of public pension funds to for-profit development of a network of technology parks adjacent to the main research centers.

[44] See http://www.erc.umd.edu/TAP/index.html.
[45] See http://www.umbc.edu/Business/Research/
[46] See http://www.baltimoredevelopment.com/bdc/about_bdc/overview.htm.
[47] See http://www.jhu.edu/~newslett/01-31-97/News/Hopkins_to_grow_on_Maryland_farm.html.

TECHNOLOGY INCENTIVES

Statewide

Among its many financing resources, DBED utilizes its "Sunny Day" funds to retain and attract life-science firms. Sunny Day is a flexible source of funding overseen by a legislative committee. The most-notable deals funded this way were Medimmune's manufacturing facility, which was hotly contested with Ohio, and Life Science Technologies' R&D laboratory. Cumulative grants and loans over the last 10 years total $43 million.

DBED also guarantees rent payments for targeted recruitments in biotechnology and information technology. Six companies, including Osiris Therapeutics, have state-backed leases committing taxpayers to $5.1 million, though the obligation decreases each year the business revives.

Maryland also offers

- **Tax abatement** for locating/expanding in qualified distressed areas, which may be claimed by R&D organizations
- **Job creation tax credit,** which also may be claimed by R&D organizations
- **R&D tax credit.**

The legislature also is considering a bill to enable sale of net operating loss carryforwards.

Regional

Montgomery County Economic Development Fund and Technology Growth Fund support life-science development. Since 1995, the EDF has made 16 grants or loans totaling $1 million, and its current appropriation is $1.1 million. TGF made its first awards in 2000. However, the county believes these programs are still inadequate to meet the need perceived by bioscience firms.

WORKFORCE

Statewide

Through the Advanced Technology Centers program, Maryland community colleges are deeply involved in workforce training for all technology sectors.

In 1998 Maryland created a Science and Technology Scholarship Program that provides support to students in science and engineering who pledge to work in Maryland following graduation. Biological sciences are among the participating disciplines. Students in community college can receive $1,000 a year; in four-year colleges the scholarship runs up to $3,000 per year. The program provided more than $2 million in scholarships (all fields) last year and is currently budgeted at $4.5 million.

Regional

The nonprofit Biotechnical Institute of Maryland[48] was created with support of MdBIO, the Abell Foundation, and others to provide customized training to help fill the growing need for

[48] See http://www.biotechmd.org/dHome.html.

qualified and specially trained lab technicians at the post-high-school level. University of Maryland at Baltimore also offers a specialized B.S. degree in biotechnology and biomedical studies.

Montgomery County Community College offers an A.A.S. degree in biotechnology laboratory technology.

SUMMARY OF KEY FACTORS

- **Application of targeted state funding** to UMBI, as a tool to leverage discretionary federal R&D funds.
- **Explicit attempt to create partnerships between businesses and federal laboratories** based in Maryland through facilities and matching-grant programs.
- **Aggressive addition of more than 50,000 square feet of wet-lab incubator space** at university sites and corporate clusters.
- **Wide range of availability of investment capital,** from very early stage (public) through facility financing and both state-assisted and fully private venture financing.

North Carolina (Research Triangle and Piedmont-Triad)

OVERVIEW

Once positioned mostly as a low-wage, non-union haven for manufacturers, since the 1950s North Carolina has carefully constructed for itself a new high-technology image. Its success is owed entirely to a patient, decades-long, state-led strategy to develop the Research Triangle Park (RTP)[49] and the metropolitan "brand" it now represents. Leaning on the research strengths of Duke, NC State, and UNC-Chapel Hill, the strategy took decades to unfold, and change came in stages. Duke and its medical center are based in Durham, a former tobacco processing center; NC State is based in Raleigh, the state capital; and UNC is in Chapel Hill, a small college town. At first, the largely undeveloped site lying between the three very different campuses could attract only manufacturers (albeit higher-value plants than before, such as an IBM assembly facility).

To break through the credibility barrier, the state created and heavily subsidized over a period of many years several large "intermediary" organizations, including in the life sciences the Research Triangle Institute (RTI)[50] and the North Carolina Biotechnology Center (NCBC).[51] These entities supported the universities' drive to achieve even greater research excellence and focused them on the importance of commercial outcomes, industrial relationships, and spin-outs. When the state finally succeeded in attracting several national environmental laboratories to the park, the image barrier was broken. The region became accepted by corporate decision makers as a suitable location for corporate R&D, including pharmaceutical and ag-biotech giants, and small firms in "discovery" or other strategic partnerships with the giants.

Now, the state is turning its attention to development of indigenous entrepreneurial ventures and to the Piedmont-Triad (Winston-Salem/Greensboro) metropolitan region, which has potential similar to Raleigh-Durham but lags far behind.

STRATEGY OWNERSHIP AND DIRECTION

Statewide

State technology strategy falls primarily under the stewardship of a statewide public/private partnership called the North Carolina Board of Science and Technology,[52] which has sponsored a multiyear strategic-planning exercise called "Vision 2030." One of the 10 recommendations of the most recent report[53] is "endorse and promote regional science and technology-based economic development programs." The document carves the state into seven regions, including

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49 See http://www.rtp.org/.

50 A stand-alone, nonprofit, contract-research institute with one major focal area in health and pharmaceuticals and another in environmental technology. See http://www.rti.org.

51 See http://www.ncbiotech.org.

52 Constituted as a board in the Department of Administration. See http://www.doa.state.nc.us/doa/science/science.htm.

53 See "Vision 2030: Mapping the Vision." North Carolina Board of Science and Technology, 2000.

Research Triangle and Piedmont-Triad, where life-science development is under way. Most other regions stress manufacturing and/or information technology.

Other recommendations of the report are

- Better alignment and coordination of various organizations for technology-led economic development in the legislative and executive branches
- Increased funding to universities for industry partnerships and pre-seed technology development
- Better data collection on technology infrastructure to support marketing and policy efforts
- Making the R&D tax credit permanent and increasing it from 5 to 10 percent, with extended carryforward and sale capability, and qualification of expenditures at in-state universities
- Continued branding and marketing of North Carolina as a high-tech state
- Training efforts focused on a "globally minded" workforce
- Expanded investment in educational technology, teacher training, and curriculum development
- Science education and public outreach focused on social and ethical issues related to progress in science and technology.

Regional

In both the Research Triangle and Piedmont-Triad regions, strategy is "owned" primarily by the chambers of commerce and business-leadership or technology councils, which are heavily involved in marketing.

In the Charlotte/Mecklenburg metropolitan region, the Charlotte Chamber of Commerce has sponsored an "Advantage Carolina" growth strategy (and marketing brand) that focuses not on the life sciences (because UNC-Charlotte is not a research campus) but rather on manufacturing, logistics, materials, and information technology.[54]

R&D Base

Statewide

The major life science R&D assets of the state are the three universities of the Research Triangle,[55] the Research Triangle Institute seeded by the state 50 years ago, the EPA and NIH federal-laboratory tenants of the Research Triangle Park, and the Bowman Gray School of Medicine of Wake Forest University in Winston-Salem. To grow this base, and direct it strategically, the state-supported NCBC offers the following categories of incentive grants:[56]

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[54] See http://www.charlottechamber.com/mainpage.cfm?category_level_id=200&channel_id=24.

[55] North Carolina has *two* land-grant institutions: NC State University and NC A&T University in Greensboro, in the Winston-Salem metropolitan area. Agricultural extension and research programs are shared between them, although NC State's program is larger by far.

[56] For a complete list, broken up into several categories for this report, see http://www.ncbiotech.org/programs/apps.cfm

Academic Research Initiation Grants—Up to $55,000 for 18 months and by invitation only, on an annual cycle;

Institutional Development Grants—If they are not coupled to major faculty recruitment packages, up to $650,000 per institution per year, they are limited to $500,000 in instrumentation and $150,000 for faculty recruitment; if they are coupled to a major faculty recruitment, there is no stated maximum.

Multi-Disciplinary Research Grants—Up to $250,000 per project, supporting large-scale, multidisciplinary, multi-investigator projects.

Regional

Recruitments supported by NCBC grants are broken down by institution as follows:[57]

Duke University
Dr. David E. Hinton, Environmental Toxicology
Dr. Bruce Kohorn, Botany
Dr. Barry Osmond, Botany
Dr. Christian Raetz, Biochemistry
Dr. John Simon, Chemistry
Dr. Thomas Tedder, Immunology

North Carolina State University
Dr. Matthew Andrews, Genetics
Dr. Becky Boston, Botany
Dr. Dennis Brown, Biochemistry
Dr. Steve Clouse, Horticultural Science
Dr. Charles C. Hardin, Biochemistry
Dr. Robert M. Kelly, Chemical Engineering
Dr. Erik Miller, Microbiology
Dr. James Otvos, Biochemistry
Dr. M. A. Qureshi, Poultry Science
Dr. Ronald Sederoff, Forestry and Biochemistry
Dr. Edward Stejskal, Chemistry
Dr. Anne-Marie Stomp, Microbiology
Dr. Kelly Tatchell, Microbiology
Dr. William Thompson, Botany
Dr. Richard van Breeman, Chemistry
Dr. Arthur Weissinger, Crop Science

University of North Carolina at Chapel Hill
Dr. Victoria Bautch, Biology
Dr. David Brenner, Medicine
Dr. Fulton T. Crews, Pharmacology
Dr. Ann Erickson, Chemistry
Dr. Bruce Erickson, Chemistry

[57] From http://www.ncbiotech.org/programs/faculty.cfm, omitting East Carolina University and UNC-Charlotte, which are not major research campuses.

Dr. Rosann Farber, Pathology
Dr. Stephen Hunt, Medicine
Dr. Nobuyo Maeda, Pathology
Dr. William Marzluff, Molecular Biology and Biotechnology
Dr. Thomas Petes, Biology
Dr. John R. Pringle, Biology
Dr. Ralph Quatrano, Biology
Dr. Lola Reid, Physiology
Dr. George Rose, Biophysics
Dr. Richard J. Samulski, Pharmacology
Dr. Oliver Smithies, Pathology
Dr. Mark Wightman, Chemistry

Wake Forest University School of Medicine
Dr. Andrew Thorburn, Cancer Research

The NCBC also is in the early stages of bringing to life a North Carolina Genomics and Bioinformatics Consortium.[58] Under NCBC's leadership, the consortium is intended to coordinate fund-raising and program management for university research in bioinformatics that is of particular interest to a founding set of life-science businesses and foundations with interest in medical science.

KNOWLEDGE TRANSFER

Statewide

To promote partnerships between the R&D base and industry, the NCBC partners with the Kenan Institute for Engineering, Technology and Science at NC State[59] to offer Collaborative Funding Assistance Grants. Projects must receive one-third match from the corporate partner and are eligible for up to $45,000 a year for up to three years in NCBC/Kenan support.

The North Carolina Technological Development Authority (NCTDA),[60] another state-supported intermediary organization, supports a Technology Development Initiative at UNC General Administration with two major components:

- Research on best practices in technology transfer, aimed at informing the 16-member UNC System, the North Carolina Community College System, Duke, and Wake Forest
- Case study research on the technology transfer system at NC State, regarded as an in-state model for UNC and others to emulate.

[58] See http://www.ncgbc.org/
[59] See http://www.ncsu.edu/kenan/html/about.html.
[60] See http://www.nctda.org/nctda/ic/overview.html.

TECHNOLOGY COMMERCIALIZATION

Statewide

To assist universities in commercializing intellectual property, NCBC offers a Proof-of-Principle Award Program, allowing technology transfer offices to apply for up to $25,000 to fund commercialization research.

Regional

In the Triangle Region, the Kenan Institute at NC State[61] also supports the following pilot commercialization programs aimed directly at strengthening the commercialization assets of universities in the region:

- **The Technology Commercialization Clinic,** through which graduate students under faculty supervision serve industrial partners of NC State, with special focus on start-ups and spin-outs
- **The Center for Innovation Management Studies,** which was relocated from Lehigh to NC State and focuses on the management of technological innovation
- **The Carbon Dioxide Patent Assessment, Acquisition, and Transfer Initiative** operated jointly by NC State and UNC-Chapel Hill
- **Nanotechnology initiative** in partnership with Applied Biosystems and the **Embrex-Viral Neutralizing Factor Technology Consortium**
- NASA Programmable Plants Workshop.

RISK CAPITAL

Statewide

Early-stage risk capital for life-science firms is available either directly from one of the state's intermediary organizations or indirectly through their creation of new investment vehicles:

From NCBC or Its Investment Vehicles

- Loans to business recipients of SBIR awards, staged at amounts ranging from $75,000 to $150,000
- Commercialization loans to businesses, ranging from $10,000 for "development" to $25,000 for proof-of-principle research
- Early-stage venture capital from the North Carolina Bioscience Investment Fund, managed by Eno River Capital, and capitalized by $10 million in state funds invested through NCBC, and $16 million from profit-motivated private investors in the region,[62] including several major regional banks, Quintiles Transnational, and the endowment fund of the Burroughs Wellcome Fund.

[61] See http://www.ncsu.edu/kenan/html/about.html
[62] See: http://www.enorivercapital.com/cgi-local/anchor.pl?pckt=about.

From NCTDA or Its Investment Vehicles

The NCTDA offers several additional sources of risk capital, which are not targeted exclusively at the life sciences:

- **The Innovation Research Fund**, which invests up to $25,000 in companies commercializing technologies, often but not always licensed from the state's universities
- **The First Flight Venture Fund**, a seed-stage venture capital fund making equity investments from $50,000 to $500,000 in emerging growth companies
- **A Fund of Funds** portfolio that uses state money to buy limited-partnership shares in privately managed local venture funds (especially those seeking local investment opportunity), alongside profit-motivated investors
- **Rural Loan Program** for emerging companies that agree to hire at least 20 percent of their workforce from families with income below the poverty line.

Regional

Unique to the NC State community is Academy Centennial Fund (formerly Centennial Venture Partners),[63] a $10 million fund capitalized exclusively by the 14 endowment foundations associated with NC State and its schools, and by an upfront commitment to management expenses made by the NCTDA. Centennial is run for profit. Its investees must have either (a) intellectual property licensed from NC State; (b) a location in the NC State Centennial Campus (see below); or (c) a sponsored-research contract with NC State. Of the 13 deals done first, 10 met the IP test, 12 had NC State principals, seven were located on the campus, and all 13 had sponsored-research agreements for a total of $1 million.

Private Sector

A.M. Pappas and Associates[64] recently closed the second round of a $102 million venture fund for life-science start-ups, targeting one-third for the Triangle region, one-third for the West Coast, and one-third in other regions.

In the year 2000, there were three bioscience initial public offerings in the Triangle Region—Inspire Pharmaceuticals, Paradigm Genetics, and Pozen.

Longleaf Ventures, the general partner for Centennial, has opened a similar fund targeted at both Winston-Salem and Charlotte (but with offices in Raleigh as well). It has raised $24 million of a targeted $30 million. Investees include banks, the state employee pension plan, and endowment funds at UNC-Charlotte and Wake Forest.

For a list of other private funds, see: http://www.academyfunds.com/af/links/index.html.

[63] See http://www.centennialventurepartners.com/cvp.htm
[64] See http://www.ampappas.com/.

TECHNOLOGY INFRASTRUCTURE

Regional

There are two main elements of specialized technology in the RTP (Raleigh-Durham) metropolitan region: RTP itself and the Centennial Campus at NC State University in the City of Raleigh. In addition, there are several state-sponsored life-science incubators spread over these two parks.

Research Triangle Park grew from a 1952 proposal by faculty at UNC.[65] An organizing committee was formed in 1956, and a parallel for-profit development company was capitalized at $700,000 by a local business person to assemble the initial 3,559 acres. At the suggestion of a local bank chairman, the organizing committee was converted to a charitable foundation that could accept both state and private contributions. All land assembled by the developer was then transferred to the foundation, and state subsidy began with construction of a home for the Research Triangle Foundation and Institute. The park now includes more than 15 million developed square feet, housing 140 organizations employing nearly 50,000 people[66] (with another 25,000 in privately owned technology parks just outside the gates). The following table shows the growth rate.

YEAR	NUMBER OF R&D COMPANIES	NUMBER OF SERVICE COMPANIES	DEVELOPED SQ. FOOTAGE	NUMBER OF EMPLOYEES
1960	3	1	204,000	500
1965	8	2	384,645	908
1970	20	6	2,396,512	8,000
1975	23	26	2,827,412	10,400
1980	40	33	6,468,912	17,500
1985	54	55	10,440,582	26,000
1990	66	47	11,620,000	32,500
1995	97	39	14,345,900	35,000
1998	106	31	15,698,070	42,000
2000	106	35	15,500,700	44,000

Table by Research Triangle Foundation. Available at http://www.rtp.org/rtpfacts/population1.html.

Centennial Campus[67] was conceived 15 years ago as a "Campus of the Future" that builds academic/industrial collaboration into its physical design. Key elements of the NC State College of Textile and its Engineering Graduate Research Center (both including life-science but not medical research) were relocated less than 2 miles from the older campus to a 1,300-acre, master-planned site that may take as may as 30 years to build out with 150 separate structures.

[65] For the "official" history, see http://www.rtp.org/about/history1.html.
[66] See "Measuring Research and Technology Park Benefits to the Region and the State: The Research Triangle Park: The First Forty Years." Research Triangle Foundation, February 1999.
[67] See http://centennial.ncsu.edu/.

Currently, there are 1.1 million square feet in 13 major buildings, representing $250 million in combined public and private investment.

Technology tenants in the Centennial Park are referred to as "partners" and are interspersed throughout the campus in several thematically coherent technology "neighborhoods." The park features four kinds of buildings:

- "Research," which are occupied by university offices, centers, institutes, and labs (and sometimes by government or nonprofit partners), developed by the university itself
- Multitenant "partners" buildings, occupied by industry partner firms requiring wet-lab space, also developed by the university
- Multitenant "venture" buildings occupied by industry partners that need only office space, developed by private firms on long-term land leases to standards specified by the university
- Single-tenant "corporate" buildings, developed privately for single tenants.

Wet-lab business incubators in the region supported and either owned or managed by NCTDA[68] include

- **First Flight Venture Center,** 28,500 square feet in a stand-alone structure at RTP
- **Entrepreneurial Development Center,** 8,900 square feet of lab space at a partners building at Centennial and additional non-lab space in a venture building
- **Life Science Center,** 20,000 square feet of lab-equipped space in Durham, focused directly on biotechnology.

Major life-science employers with headquarters or facilities at RTP[69] include

- Glaxo Wellcome (4,885 employees)
- Research Triangle Institute (1,750)
- U.S. EPA (1,734)
- U.S. Department of HHS/NIH/National Institute of Environmental Health Sciences (1,000)
- Aventis Crop Science (560)
- Covance Biotechnology Services (450)
- Novartis Agribusiness Biotechnology Research (260).

In the Winston-Salem (Piedmont-Triad) region, a 24-acre downtown Piedmont Triad Research Park is being developed by the North Carolina Emerging Technology Alliance.[70] The park has been on the drawing board since 1994 but has moved forward only intermittently. Key tenants include two off-campus affiliates of Wake Forest, Longleaf Venture Fund (see "Risk Capital"), and biotech firm Amplistar. The research division of NC A&T University is frequently mentioned as a partner but is not yet involved.

[68] See http://www.nctda.org/nctda/bi/rt_incubators.html.
[69] See http://www.rtp.org/rtpfacts/lgemployer.html.
[70] See http://www.sbtdc.org/tech/institute/PTRP.htm.

TECHNOLOGY INCENTIVES

For several years, North Carolina has had in place the William S. Lee tax credit program for job expansion, but several technology sectors consider it overly focused on manufacturing. The state also has an R&D tax credit.[71]

WORKFORCE

Statewide

Among the better-known intermediary organizations in the state is the Council for Entrepreneurial Development (CED),[72] headquartered at RTP but serving a statewide audience. Although CED has active programs in capital formation (venture conferences, etc.), its major thrust has always been in educating and mentoring entrepreneurs, who are seen as a human resource of critical importance to the state.

The North Carolina School of Science and Mathematics (NCSSM) dates to 1978, about midway through the RTP strategy.[73] Based in the historic tobacco-processing city of Durham, NCSSM was designed as a two-year residential magnet school. It provides the state's most talented students (including children of technology workers recruited to the Triangle) with an intensive academic experience and catalyzes curriculum improvements throughout the state. Effectively a charter school, NCSSM is 80 percent state supported, with the balance of its funding raised from parents, alumni, foundations, and companies.

Additionally, NCBC offers[74]

- **Education Enhancement Grants** and Mini Grants for K-12 curriculum development focusing on biotechnology
- **Summer MBA Internships** that pay the salaries of first-year MBA students placed with biotech firms statewide, supporting projects of up to 220 work hours.

Regional

The Kenan Institute provides stipends for outstanding graduate and postdoctoral students in biotechnology at the three RTP universities.

SUMMARY OF KEY FACTORS

- **Long-term, patient commitment.** The state strategy leaning on development of RTP is now 45 years old. Several of the key intermediary organizations were created in the 1980s or earlier.

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71 For background on the Lee credit and the state R&D tax credit, see http://www.commerce.state.nc.us/finance/incentives/tax/.
72 See http://www.cednc.org/.
73 See http://www.ncssm.edu/.
74 See previously cited web page and http://ncbiotech.org/programs/interns.cfm.

- **Brand awareness.** The state recognized early that its university sector was the key to remaking its image. Identified with two aging manufacturing sectors and a small college town, the Raleigh-Durham region had to entirely reinvent its image.
- **Attention to entrepreneurship.** Despite the state's ultimate success at inward attraction of corporate investment to the RTP region, leaders have never lost sight of the ultimate goal of developing indigenous entrepreneurship.

Ohio (Cleveland, Columbus, and Cincinnati)

OVERVIEW

The State of Ohio has three widely separated, large metropolitan areas that can claim significant life-science assets: Cleveland, Columbus, and Cincinnati. Cleveland probably has the highest national profile, with scattered success stories like device-maker Steris, several promising genetics firms in the financing pipeline, and nascent cooperation between its research institutions and federal laboratories. Columbus so far has fairly little to show despite Ohio State University's medical center, research park, and aggressive "industry partnerships" office. Cincinnati has been trying since 1998 to advance a regional life-science strategy. Ohio also has additional R&D strength in the smaller and also widely separated communities of Athens and Wooster (home to Ohio State's agricultural research), but neither has been the focus of economic development.

Lack of success cannot be attributed to indifference by the state government. Ohio created the Thomas Edison Program within its Department of Development in the 1980s, as its entry in the race for technology-led development. The Edison Program has invested heavily over the years in business incubation and technology "centers," including the life-science focused Edison BioTechnology Center (EBTC). Rather, Ohio's lag seems better explained by political factors—leaders' unwillingness to view the metropolitan regions as a *system* over which state investments should be optimized rather than simply allocated—and by cultural factors, notably the overall conservatism of its major public and private universities, and the unwillingness until recently of major institutions within a single region to work well together.

While the state has repeatedly attempted to mount large-scale R&D initiatives, the diversity of research assets across the state would make such a program quite expensive if all regions were to be treated equally, and has never been mounted. Instead, the Governor's office uses a discretionary fund to make targeted grants intended to leverage specific opportunities for federal funding.

STRATEGY OVERVIEW AND DIRECTION

Statewide

Overall, technology at the state level is driven by the Technology Division of the Ohio Department of Development[75], which operates the Edison Program, and by the Governor's Office of Science and Technology,[76] which jointly with the Department administers the Technology Action Fund (TAF).

The Edison Program ($25 million in FY 2000) funds a series of technology centers designed to connect industrial sectors important to Ohio to government and academic partners, in an effort to boost their competitiveness. These Edison Technology Centers combine state and industrial funding either to conduct pre-competitive industrial R&D directly in their own facilities or to

[75] See http://www.odod.state.oh.us/tech/.
[76] See http://www.odod.state.oh.us/gost/default.htm.

subcontract tasks to outside entities. Several of these centers are dedicated to manufacturing or advanced materials technology, and are located variously in Cleveland, Cincinnati, Toledo, Dayton, Akron, and Kettering. One—the EBTC[77]—is devoted to the life sciences. EBTC is headquartered in Cleveland, the largest life-science center in the state, and has offices in Columbus, Cincinnati, and Athens. EBTC itself does not conduct research but provides business-development services, administers seed funds and associated incubators, contracts to two university-based centers, and serves in effect as a joint institutional/corporate interest group for the bioscience sector in Ohio. Overall, the Edison Program is fairly static. While centers have been added and dropped over time, there is little overall change in the scheme of the program. By contrast, the TAF is designed to respond flexibly to opportunities. It is described in "R&D Base."

In 1990 the Ohio Department of Development commissioned a preliminary assessment of the agricultural biotechnology sector in Ohio[78] but has not taken active steps to develop or implement a strategy.

Regional

Since the time of municipal default in 1979, Cleveland's civic and business community has been intent on a reinvention of the economy. With leadership from The Cleveland Foundation and the Federal Reserve Bank of Cleveland, several key organizations were established, including a regional economic-research center at Case Western[79] and Cleveland Tomorrow, a CEO-level leadership group. Cleveland Tomorrow in turn spun out a Technology Leadership Council, since renamed NorTech.[80] Cleveland's life-science strategy evolved over time from a base formed in the mid to late 1990s:

In 1997, a report prepared for the Shorebanc Cleveland Corporation (a community development financial institution tied to Chicago's Shorebank Corporation and supported by Cleveland area foundations) recommended that the region adopt a "cluster-based" strategy for economic and community development.[81]

In 1998, a coalition of Cleveland Tomorrow, the Growth Association of Cleveland, the Port of Cleveland, and the Akron Development Board sponsored a study to identify economic clusters of promise.[82] The study identified the region's "foundational" and "capstone" industrial clusters and pointed to two emerging clusters, including biomedical. It identified strategic issues but did not make specific recommendations.

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77 See http://www.ebtc.org/.

78 Thomas L. Sporleder. "An Initial Assessment of Agricultural Biotechnology in Ohio: A report to the Ohio Department of Development and the Edison Biotechnology Center." Edison Biotechnology Center: August 1999. Available on line at http://www.ebtc.org/EBTC%20Final%20PDF%20Format%20082799.pdf.

79 The Center for Regional Economic Issues, at http://weatherhead.cwru.edu/rei/.

80 See http://www.nortech.org.

81 Alan Okagaki & Associates. "Building The Entrepreneurial Economy: Regional Growth Economic Opportunity." Draft dated September 1997. Not available on-line.

82 "Regional Economic Development Strategy Initiative: Cluster Analysis Discussion Document." June 1998. Not available on-line.

At about the same time, a "biomedical cluster group" was broken out for further study, and conducted a best-practice analysis[83] that highlighted new directions for the technology transfer office at Case Western, by examining Stanford, MIT, Baylor College of Medicine, and University of Wisconsin. In addition, a working paper examined the biomedical cluster and "opportunities for collaboration."[84]

In the year 2000, the Generation Foundation—an unusual charity supported by wealthy individuals and private foundations in the Cleveland region—sponsored a study[85] on "Creating a Biomedical Economy" that resulted in adoption of a specific and detailed life science cluster strategy, cumulating to $200 million in planned investment.

The life-science strategy is to be executed by BioPark, a newly created collaboration of Case Western, Cleveland Clinic, and University Hospitals. BioPark is envisioned as both a vehicle for collaboration (on researcher recruitment and technology transfer initiatives) and the sponsor of a 200,000-square-foot bioscience research park situated somewhere between Cleveland's Midtown and University Circle neighborhoods. BioPark's real estate element would include

- A new, $20 million, centralized **animal resource facility** (mouse lab) available to both academic and industrial research projects
- A new, $8 million, shared facility for **biomedical analytical instrumentation** (mass spectroscopy and NMR) supporting academic and commercial users
- A $30 million, 65,000-square-foot stand-alone **center devoted to BioMEMS** (micro-electro-mechanical systems).

BioPark has received $8.5 million from the TAF, including

- $1 million for BioPark itself, allocated to the BioEnterprise incubator (see "Technology Infrastructure")
- $1 million to Cleveland Clinic for BioMEMS work
- $1.65 million for an early-stage seed fund (see "Risk Capital").

Efforts to plan a regional technology strategy in Columbus have been steadily strengthening. In 1997, the Industry & Technology Council of Central Ohio[86] developed a skeletal strategy[87] whose principal elements pertinent to the life sciences were

- **Expand Ohio State University's Science and Technology Campus** (see below) and associated incubator
- **Expand availability of seed capital** through creation of a local venture firm

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83 "Greater Cleveland Growth Association: Biomedical Cluster Group: Best Practices Analysis." Undated. Not available on line.

84 "The Biomedical Cluster in the Northeast Ohio Region: A Briefing Paper: Regional Economic Development Strategy Initiative." Palo Alto, Collaborative Economics: June 1998. Not available on-line.

85 Jonathan Murray. "The Northeast Ohio Life Sciences Cluster: Opportunities for a New Economy: Report to the Generation Foundation." Cleveland, September 2000. Available on-line from http://www.generationfoundation.org/publications.html.

86 See http://www.ind-tech.org/

87 See "A Technology Strategy for Central Ohio." Columbus: Industry & Technology Council. Undated, but probably 1997. No longer available on-line.

- **Streamline the process for promoting commercialization of university technology,** including by resolution of uncertainties pertaining to state law on conflict of interest.

Later, the Columbus Technology Leadership Council and the EBTC office in Central Ohio commissioned from Battelle a full-scale "Central Ohio Bioscience Strategy for the 21st Century." The main recommendations of this strategy are

- **Build and strengthen the bioscience R&D base** around core competencies:
    - Bio and health informatics
    - Bioengineering and medical-product development
    - Food science technology and agricultural biotech
    - Contract drug development services
    - Disease assessment and treatment.
- **Promote connectivity and collaboration** among the major bioscience drivers:
    - Establish connections with region's core economic sectors, such as insurance, retail, food, IT, and manufacturing
    - Secure federally designated research centers or institutes at large scale.
- **Enhance the entrepreneurial culture**
    - Develop bioscience commercialization and pre-seed funds
    - Expand linkages between college of business and bioscience entrepreneurs
    - Build the entrepreneurial management pool.
- **Improve the business climate**
    - Encourage a City of Columbus technology zone close to OSU and its Science and Technology Campus
    - Encourage Ohio public pension funds to invest in a new generation of venture firms with specific interest in bioscience
    - Initiate a concerted retention effort and within-region education campaign.
- **Institutionalize a Central Ohio Bioscience agenda**
    - Use the EBTC as an advocate at the state level
    - Promote state encouragement for Columbus, Cleveland, and Cincinnati to develop their core competencies.

Cincinnati has actively planned a technology strategy[88], but it is IT-oriented. In the life sciences, Cincinnati has studied its strategic position by data analysis conducted jointly by the BIO/START incubator (see below) and the Thomas Edison Center. Butler County, north of Cincinnati, has laid out a general technology strategy, featuring a $100 million investment to be

[88] See "Building Cincinnati's New Economy: Opportunity Analysis & Roadmap to Implementation." Cincinnati: December 2000. No longer available on-line. See also Patricia J. Snider and Carol Frankenstein. "Report of the Cincinnati Life Science Task Force." Cincinnati: BIO/START: 1999.

financed by a half-cent rise in sales tax. Proceeds will be used mainly for IT infrastructure, but biomedical technology is identified as an area for future focus.

R&D BASE

Statewide and Across Regions

Ohio's principal research assets are Ohio State University (Columbus and Wooster), Case Western University (Cleveland), Ohio University (Athens), University of Cincinnati, the Cleveland Clinic Foundation, and two important federal laboratories: NASA Glenn (formerly Lewis) Research Center in Cleveland and Wright-Patterson Air Force Base in Dayton. The state operates several programs to promote building the R&D base:[89]

- The **TAF** (see above), which has been in operation since 1998 ($15 million in FY 2000). It is designed to provide seed funding for initiatives at either university campuses, federal laboratories, or industry consortia that will leverage substantial federal funding. For example, TAF has been used to fund a MEMS consortium that links the research universities with NASA Glenn.
- **The Hayes Investment Fund**, which provides grant support for equipment and facilities necessary to enable research collaborations between institutions or interest-free loans in the case of noncollaborative university research.
- **The Research Challenge Fund** ($19 million in FY 2000), which provides general research support through line-item appropriations to universities on the basis of past performance in attracting external research support.

The legislature's intent to channel $1 billion of tobacco settlement funds to an "Ohio Plan" for R&D expansion has been stalled by political turmoil caused by judicial rejection of the state's funding system for K-12 education.

KNOWLEDGE TRANSFER

Statewide

In response to lobbying by constituencies of the EBTC, the state recently used part of its tobacco settlement to fund a university/industry challenge grant program in the Ohio Board of Regents. This is one of seven trust funds established under the plan for the tobacco settlement and the only one to focus on biomedical research. The Biomedical Research and Technology Transfer Trust Fund requires collaborations "between organizations and give[s] strongest priority to proposals of the highest scientific merit that involve partnerships with and financial support from biotechnology and pharmaceutical companies."[90] However, in view of the continued failure to finance the Ohio plan, Ohio's universities have staked a strong claim on this fund for financing technology infrastructure rather than direct partnerships. The fund currently states that it expects to make "very few large awards, in the range of $5-$15 million" each. Focal areas are

[89] See http://www.regents.state.oh.us/rsch/rschsupport.html.
[90] See http://www.ebtc.org/brtt%209-7-01.htm.

- Human genetics and genomics
- Structural biology
- Biomedical engineering
- Computational biology
- Plant biology
- Environmental biology.

TECHNOLOGY COMMERCIALIZATION

Statewide

The most important state initiative to promote commercialization of university technology was an amendment in 2000 of the Ohio Code (§3345.14) to explicitly delegate to the trustees of Ohio's public universities the right to set technology transfer policy and practice, including for faculty ownership in spin-out companies.

In terms of funding, the EBTC offers a "flex fund" program that awards up to $50,000 to companies for market research, business planning, patent expenses, and limited laboratory or clinical projects.

Regional

The Cleveland Clinic Foundation has recently completed a reorganization and recapitalization of its wholly owned commercialization company, NovaMedics, into an in-house commercialization arm to be known as CCF Innovations. This will move the organization from a classical venture capital mission to one more closely attuned to the commercialization needs attendant on CCF-initiated inventions.

In Columbus the OSU Science and Technology Campus operates as a subsidiary a Technology Commercialization Company. [91] TCC has received a TAF grant of $700,000 to operate a Technology Validation Fund. This pre-seed fund is aimed at evaluation, protection, and early-stage advance of intellectual property emerging from OSU's College of Engineering. No direct analogue exists for the life sciences, but TCC represents a vehicle for such a fund when it can be raised.

RISK CAPITAL

Statewide

Seed funding is available statewide from the EBTC BioInvestment Fund.

Until 1995, Ohio public-pension law defined the investments that funds were allowed to make. In the alternative-asset class, the law required that funds place their money only with those venture funds that opened an Ohio office, promised best efforts to make half their investments in Ohio, and where that amount would be at least equal to the investment of the pension fund. This

[91] See http://www.stcc.org/TCC/TCC_Intro.html.

resulted in creation of a wave of venture firms with Cleveland offices or headquarters. Subsequently, the "legal list" approach was scrapped, and Ohio public pension funds now invest solely by a "prudent person" standard. By 2001, according to a report to the TAF board[92], some $4 billion of venture capital was under management in Ohio through 21 firms with offices located in the state. However, the report cautioned, that

- More than 40 percent of that amount is managed by funds whose *primary* office is not Ohio.
- Only 4.3 percent was in funds that would consider seed-stage deals in the life sciences.
- Only two funds focus exclusively on Ohio, while as many as 33 percent have a Midwest orientation, with the balance national.
- Sixty-two percent of the in-state capital was based in Cleveland, 20 percent in Cincinnati, 16 percent in Columbus, and 2 percent in Dayton and Athens together.

The same TAF committee has studied the availability of angel capital.[93]

Regional

TAF awarded Cleveland area sponsors $322,000 for Early Stage Partners, a life-science-oriented venture capital fund. The TAF contribution must be matched by private investors, and the fund is seeking $50 million in total capitalization. A similar fund in the Columbus region also received TAF support, matched by contributions from Battelle, Ohio State University, and several local companies.

TECHNOLOGY INFRASTRUCTURE

Statewide

From nearly its outset, the Thomas Edison Program has included ongoing funding for Edison Technology Incubators. Not all of these are wet-lab equipped or life-science oriented, but those that are so equipped are highlighted by region below.

Regional

In Cleveland, there are several existing technology incubators (see below) and a new initiative for a BioPark. The BioPark is a joint effort of the Cleveland Clinic Foundation, Case Western Reserve University, and University Hospitals. The first phase of BioPark will be a 25,000-square-foot incubator called BioEnterprise.

Incubators in Cleveland that are already operating include

- **Edison Technology Incubator**[94]**—**A 25,000-square-foot wet-lab incubator in a building at Case Western University. ETI is operated by Case Western's nonprofit technology- and community-development company, Enterprise Development Inc.[95]

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92 "Venture Capital in Ohio: Report to the Technology Action Board." TAF Subcommittee on Early Stage Capital. January 2001. Not available on-line.

93 Stacy Noel Condon. "Ohio Seed Capital/Angel Investing: Existing and Emerging Resources." TAF Committee on Early Stage Capital. April 2001. Not available on-line.

94 See http://www.enterprise-development.org/starting/eti_facilities.html.

95 See http://www.enterprise-development.org/.

- **BioEnterprise**[96]—A second floor in the same building, also operated by EDI, and targeted toward later-stage bioscience firms that have some connection with the EBTC.
- **LIFT**[97]**—**The "Lewis Incubator for Technology" operated by EDI in conjunction with the NASA Glenn (formerly Lewis) Research Center. LIFT has two facilities: its wet-lab incubator is based in suburban Strongsville.

In Columbus, the operating incubator is

- **Business Technology Center**[98]—a 26,600-square-foot wet-lab-equipped incubator located in the Ohio State University Science and Technology Campus[99] (research park).

In Cincinnati, the key infrastructure element is

- **BIO/START—**a nonprofit wet-lab incubator involving cooperation from the University of Cincinnati, several area hospitals, and Procter & Gamble, but which is struggling to refinance the debt it took on in its start-up period.

TECHNOLOGY INCENTIVES

Ohio offers a Technology Investment Tax Credit, unusual in that it is administered not by the state revenue department but by the Ohio Department of Development and the Edison Centers.[100] There is also a conventional R&D tax credit.

SUMMARY OF KEY FACTORS

- **Highly flexible opportunity funding**—While Ohio has not excelled at full-scale programs to build the R&D base, it has one of the most flexible discretionary programs for meeting targets of opportunity, the Technology Action Fund.
- **Regional strategy building—**Each of the three major metropolitan areas has an explicit, written life-science strategy (albeit at varying levels of development and without state pressure to integrate or coordinate them).
- **Sophisticated range of capital sources—**Ohio has for many years used its pension funds to encourage the formation of indigenously managed venture capital and has expanded this activity into the seed arena through the EBTC intermediary.

96 See http://www.enterprise-development.org/starting/bio_facilities.html.
97 See http://www.liftinc.org/.
98 See http://www.btccolumbus.com/.
99 See http://www.stcc.org/
100 See http://www.odod.state.oh.us/tech/titc/.

Oklahoma (Oklahoma City)

OVERVIEW

For some years Oklahoma has been quietly building a life-science research base, complemented by extremely practical focus on technology transfer and commercialization. Like several Mountain and Southwest states, Oklahoma took from the oil-price bust of the 1990s the lesson that it must diversify its economy. Tulsa, once known only for oil services and manufacturing, emerged in the later half of the decade as a center for information technology and communications services. In the life sciences, Oklahoma City is well established as the clear leader, despite pockets of scattered strength elsewhere, such as the Stillwater campus of Oklahoma State University; the Norman campus of Oklahoma University; and an unusual private foundation based in Ardmore, a small city halfway between Oklahoma City and Dallas/Fort Worth.

Strategy is driven strongly by the state agency known as the Oklahoma Center for Advancement of Science and Technology and by the nonprofit intermediary it supports, the Oklahoma Technology Commercialization Center (OTCC). The latter aggressively leverages its custody of a state-sponsored pre-seed technology development fund (and its careful cultivation of a statewide network of informal "angel" investors) to maintain moderately tight control over the process of developing Oklahoma-based early-stage technology ventures to the point where they are can be financed by the private sector. Overall, federal funding for the life sciences is still weak on a population-adjusted basis; but, signs indicate that the administration is coming to grips with the need for major investments. Oklahoma has long been a leader in efforts to build locally managed venture capital that will look for local deals.

STRATEGY OVERVIEW AND DIRECTION

Statewide and Distributed Across Regions

State technology strategy is driven by the Oklahoma Center for the Advancement of Science and Technology[101], a state agency based in the capital. OCAST's statutory mandate is fourfold:

- **Support basic and applied R&D**
- **Facilitate technology transfer** and commercialization
- **Stimulate seed-capital investment** in firms commercializing new technology
- **Encourage manufacturing modernization.**

R&D BASE

Oklahoma's universities with life-science assets are Oklahoma State University (OSU), one of the two land-grant institutions[102], with agricultural research located in Stillwater; and Oklahoma

[101] See http://www.ocast.state.ok.us/.
[102] The other is Langston University, an historically black institution.

University (OU), with a main science and engineering campus in Norman, a Health Sciences Center in Oklahoma City (the hospitals associated with the school are now independently operated), and a second medical college in Tulsa.

However, there are two additional important and unusual resources:

- **The Oklahoma Medical Research Foundation (OMRF),** a private nonprofit biomedical research institution based in Oklahoma City, with some similarities to the Stowers Institute in Kansas City (more detail below)
- **The Samuel Roberts Noble Foundation**[103], a $1 billion (assets) private operating foundation based in Ardmore whose mission includes: "enhancing plant productivity through fundamental research and applied biotechnology."

Statewide

OCAST offers an Oklahoma Health Research Program[104], though which modest-sized projects in the university, nonprofit, or commercial sectors are funded up to three years at $45,000 per year. To take development of the state's R&D base to a higher level, Governor Keating announced last June the establishment of a $1 million trust fund to serve as seed money for a new Oklahoma Institute of Technology, an intermediary organization intended to develop and amplify research strengths in IT, engineering, and biotechnology at all participating research institutions.[105] The trust fund was created through support of an unidentified private foundation. Its ultimate goal is to reach a $100 million endowment. The main goals of the institute are

- **Attracting and retaining outstanding faculty** through public-private partnerships to support endowed chairs, scholarships, and research grants
- **Partnering to set standards for curriculum**
- **Facilitating public-private research and development projects** using the facilities of public higher education institutions
- **Certifying courses and programs in IT and biotechnology**
- **Coordinating distance-learning strategies**
- **Developing strategies for workforce training**
- **Upgrading and enhancing rural technology infrastructure**, including telemedicine capabilities.

In addition, the State Chamber of Commerce and its Technology Council have proposed that Oklahoma ready itself as home to a National Bioinformatics Collaboration Center[106], including development of "collaboration software" to help structure the data necessary for commercial exploitation of medical and agricultural research. The strategy is viewed as a way to tie together the life-science strengths of Oklahoma City with secondary metropolitan regions statewide,

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103 See http://www.noble.org/Admin/WhoWeAre/index.HTM.
104 See http://www.ocast.state.ok.us/INFOohr.HTM.
105 See text of the legislation at http://www2.lsb.state.ok.us/2001-02SB/sb694_enr.rtf
106 See "Leveraging a Bioinformatics Collaboration Center into High Paying Jobs in Oklahoma." Oklahoma City: The State Chamber, February 2001. Available on-line at http://www.okstatechamber.com/bioinformatics/bioinformatics.pdf.

including especially sites of agricultural research such as Stillwater and Ardmore and the IT commercial hub in Tulsa.

Regional

OMRF was founded in 1946 by alumni of the OU School of Medicine[107] who were committed to attracting new research-oriented medical faculty to Oklahoma City, at a time when the OU medical center was not committed to research and had no facilities for it. Land was deeded by the state, a plot immediately adjacent to the OU medical school, and leading citizens raised $2.35 million in initial endowment, supplemented several times by later bequests and ongoing annual giving. The OMRF research campus has grown substantially over the years, and its annual budget is now $30 million. It operates as an independent entity that is highly integrated with the facilities and strategies of the OU Health Sciences Center. OMRF claims recent breakthroughs in cardiovascular disease, Alzheimer's disease, and Lupus, and houses the only Howard Hughes Medical Investigator in the state. OMRF has spun off several local biomedical companies. Its president has published an article referencing with praise the Kansas City Life Sciences Institute initiative and committing to a role in growing Oklahoma's NIH funding per capita.[108]

Founded in 1945 by an oilman, the Noble Foundation now includes a biomedical division that is collocated with OMRF in Oklahoma City and Ardmore-based divisions of plant biology and forage biotechnology. Noble is a partner in the Oklahoma Health Center Research Park profiled in "Technology Infrastructure." It also operates a $5 million grant program with surpluses remaining after its operating and capital needs are met. When there is a need to gather plant biology researchers from around the state, Noble has chosen its facilities in Oklahoma City as a central gathering place for meetings and seminars.

KNOWLEDGE TRANSFER

Statewide

OCAST operates an Applied Research Support Program[109] that offers matching grants to encourage university/industry collaboration on projects that will benefit the state's economy. Life science projects have been among those funded.

TECHNOLOGY COMMERCIALIZATION

Statewide

Since 1998 OCAST has contracted for commercialization service to OTCC, a private, nonprofit corporation headquartered in Oklahoma City but with field offices in four other metropolitan regions. OTCC has a staff of 13 (rising to 15) supported by an annual grant of $1.7 million from OCAST. Core staff provide intensive management assistance to technology entrepreneurs in

[107] See the excellent history at http://www.omrf.ouhsc.edu/OMRF/Information/Welcome.asp.
[108] J. Donald Capra, "The Economic Promise of Biomedical Research." *The Journal Record.* February 28, 2001. Reprinted at http://www.ouhsc.edu/OMRF/News_Releases/PresidentsNewsPage/20010228.asp.
[109] See http://www.ocast.state.ok.us/INFOoars.HTM.

their regions, and they also nurture regional networks of angel investors and professional-service providers.

OTCC places heavy stress on guiding all entrants to its program through a six-stage commercialization model (based on the general "stage-gate" literature), which it has reduced to writing and makes freely available to entrepreneurs and others.[110] OTCC charges modest fees for providing services at certain stages of the model; but, more importantly, it uses the model as a tool for explaining to its clients what to expect from the process of commercializing a technology or an innovation. For example, the model is used to expose inventors (whether academic or independent) to the idea that they may not make the best CEO for the business in the long run. In the short run, OTCC may either train and develop the incumbent founding management or help recruit professional management. If the inventor is university affiliated, OTCC will try to recruit outside management 70 percent of the time; if the inventor is independent or from the private sector, the ratio is reversed and the majority receive assistance, counseling, and coaching in becoming better managers.

RISK CAPITAL

Statewide

Oklahoma's initiatives in capital access range from very early stage, pre-seed funding offered by government agencies and their contractors to a market-oriented venture-capital initiative that relies on a "fund of funds" approach.

OCAST directly operates several programs to encourage early-stage companies to take advantage of the federal Small Business Innovation Research Program:[111]

- Incentive grants to defray part of the cost of **Phase I proposal preparation**
- Matching fund grants to Phase I winners that encourage **preparation of Phase II proposals**
- Incentive funds to encourage **STTR applications in conjunction with universities.**

In addition, OCAST funds OTCC at $1 million a year to operate the Oklahoma Technology Business Finance (TBF) Program, a quasipublic, pre-seed fund operated on a payback basis. Administering the TBF gives OTCC a tool to help early-stage companies explore management and commercialization options, and additional leverage to enforce compliance with the commercialization model. Since the TBF money comes from the state, OTCC is not permitted to take equity in return for its early-stage investments, but it does contract to receive paybacks from successful ventures, at a multiple of between 2x and 5x investment depending on perceived risk. All TBF awards must be matched 3:1 by other sources of support, of which one part must be cash commitments. All proceeds will be deposited in a TBF revolving fund.

Only when OTCC says they are ready are entrepreneurs introduced to the Oklahoma Capital Network, a group of 300 "angels" who invest both individually and through as many as a dozen organized limited liability companies. Although many of these investors and vehicles existed before OTCC did, they have been energized and well tended by OTCC, which provides quality-

[110] Oklahoma Technology Commercialization Center. *Technology Commercialization Model: From Concept to Market.* Oklahoma City, Oklahoma: May 2000.

[111] See http://www.ocast.state.ok.us/INFOsbra.HTM.

controlled deal flow. OTCC tries to get clients ready for this "A" round within 180 days of initial entry and then targets investment of between $1 million and $5 million. Entrepreneurs are allowed to make contact only through OTCC and are tightly controlled as to protocol and presentation content. Investors active in the program say that this has dramatically improved the quality of the deal flow they see.

Originally, it was envisioned that OTCC's services would stop at the point of closing the A round, but since then it has become clear that the A round investors *want* OTCC's continued involvement through the B round, or acquisition of formal venture capital. At present, only a few deals have made it through the "funnel" to the B round. As of February 2001, the Oklahoma Capital Network had reviewed 114 A round investment opportunities from the more than 500 clients who signed on with OTCC. In all, OTCC clients entered the year with more than $35 million in investment capital generated through this process.

In 1992, the state created an Oklahoma Capital Investment Board (OCIB), which operates as a "fund of funds." As described by an excellent case study prepared by the Rural Policy Research Institute (RUPRI)[112], OCIB's capital comes from institutional lenders and investors through the Oklahoma Capital Formation Corporation. This corporation receives a loan from institutional investors who are guaranteed an 8 percent return. The money is invested by OCIB in privately managed venture funds which pool it with money they raise elsewhere and invest it in Oklahoma companies. The state gets a share of the profit; but, if earnings fall below the guaranteed return, the state makes up the difference with tax credits. Income above the guarantee is re-invested by OCIB, which hopes eventually to eliminate its dependence on borrowed institutional capital. To quote from the RUPRI case study:

> In selecting partner funds, OCIB conducts due diligence on the fund. OCIB is looking for . . . funds that provide a good strategic fit with the Oklahoma economy. For example, one partnership may focus on early stage biotech ventures while another may focus on later stage, more traditional manufacturing activities, both activities of importance to Oklahoma.

According to RUPRI's interview with OCIB in July 2001, OCIB seeks to invest $1 million to $5 million in each fund and to maintain a 10 to 20 percent share of overall ownership. "The Board estimates that a $1 million to $5 million investment will be sufficient to encourage the fund to actively seek Oklahoma deals, but the 10 to 20 percent share ensures that a number of other investors (limited partners) are conducting due diligence on the fund's investments." OCIB has committed $26 million to eight private funds ($18 million drawn down), which have invested $66 million in 11 Oklahoma firms. Some of its investee funds are based outside the state but make investments in-state, as is the case with the Pacesetter Growth Fund of Texas. The annual average internal rate of return since inception in 1993 is 29.6 percent.

[112] RUPRI is a collaborative of Iowa State University, the University of Missouri, and the University of Nebraska. See Case Study P2001-11 by the Rural Policy Institute's Rural Equity Capital Initiative at http://www.rupri.org/pubs/archive/reports/P2001-11/cs4.html.

TECHNOLOGY INFRASTRUCTURE

Regional

The Oklahoma Health Center Research Park is being developed by the state-chartered Medical Technology and Research Authority on a 23.5-acre tract adjacent to the Health Sciences Center.[113] The private, nonprofit Presbyterian Health Foundation is purchasing sites within the park and will be the owner/developer of new structures. Two mid-rise multitenant structures of 25,000 square feet each have already been constructed.

OTCC also is developing a network of three technology-business accelerators (incubators). The life-science incubator is planned for Oklahoma City, while Ponca City hosts advanced materials, and Tulsa is the site for IT/telecom.

TECHNOLOGY INCENTIVES

Statewide Across Regions

Oklahoma has freely transferable tax credits for investors in qualified venture-capital companies (see OCIB discussion in "Risk Capital"). The state also has an Enterprise Zone program in depressed counties and inner cities and at least three conventional incentive programs for which R&D companies qualify, although no R&D tax credit.[114]

WORKFORCE

Statewide

OCAST funds faculty and students at Oklahoma universities to participate in internship programs with Oklahoma-based companies.[115] Each partnership is funded at $10,000 to $50,000 per year for up to two years.

Regional

Oklahoma City Community College offers an A.A.S. in biotechnology.

SUMMARY OF KEY FACTORS

- **Critical mass concentrated in Oklahoma City**—The state's business, civic, and scientific leadership has placed its major bet on Oklahoma City, encouraging pockets of excellence elsewhere to coordinate through that node.
- **Careful tending to need for indigenously managed capital**—For many years Oklahoma has aggressively used its financial leverage to attract indigenous managers of venture capital, who can receive deal flow from the early-stage investment networks that are now developing.

[113] See the architectural master plan at http://www.milesassociates.com/Pages/Projects/research_park.htm.
[114] See http://domino1.odoc.state.ok.us/newhome/biti.nsf/pages/Tax+Incentives+Pro+Forma+Overview.
[115] See http://www.ocast.state.ok.us/INFOfsip.HTM.

- **In early stages of boosting R&D base**—Despite a reality that exceeds national reputation, the state has realized that it will need to take university-based R&D to a new level and is in the early stages of planning how to do so.

Pennsylvania (Philadelphia, Pittsburgh, and State College)

OVERVIEW

Pennsylvania is 20 years and counting into a comprehensive effort to reorient its economic-development strategy and apparatus away from "smokestack chasing" and toward the creation and retention of fast-growing, technology-based businesses. It is the first state to have created an agency for this purpose, the Ben Franklin Partnership Program.[116] The state has had some success in the life sciences, which cannot necessarily be attributed directly to the Ben Franklin Program but which surely stems from the technology-friendly atmospherics created by three successive Governors who kept the program in their budgets and their promotional strategy.

The state is categorized in life-science industry statistics as "Mid-Atlantic" and registers mainly by virtue of the Philadelphia metropolitan region. This southeastern region of the state counts among its advantages an extremely powerful base of basic biomedical science and clinical research and a strong economic connection to the Princeton and central New Jersey research corridor. In addition, the Philadelphia region has a heritage as a center of specialty chemical processing, and its western suburbs have long been home to the R&D facilities of several major pharmaceutical firms, including those with New Jersey ties. Without question, many life-science start-ups cluster in the region to engage in strategic partnerships with these larger entities. Altogether, the five counties composing the metropolitan region host 500 biomedical establishments, representing 43 percent of the statewide total. Probably the best known among the biotechs is Centocor, which was started in the inner-city University City Science Center described in "Technology Infrastructure" but has long since moved to suburban Malvern.

In the southwestern part of the state, the Pittsburgh metropolitan region has registered strong success in twice "reinventing" its image: first from a smoky steel-processing center to a gleaming corporate headquarters town and then again to a center of advanced technology. Much of Pittsburgh's success at start-up formation has come in the IT sector, owing to heavy and sustained federal investment in research at Carnegie Mellon University's Software Engineering Institute. Blessed with a strong base of Fortune 500 headquarters and branch operations, as well as an unusually high number of aggressive private foundations, the community also was early to organize several interrelated planning, promotional, and networking groups. Pittsburgh is now engaged intensively in planning to capitalize on the region's biomedical strengths, which include an unmatched clinical program in organ transplantation that has led to deep strengths in tissue engineering, which is important in turn to artificial-organ development. Finding and exploiting synergies between biomedical science at Pitt and engineering science at CMU is the great hope of the region.

The third region of the state to have potential in life-science development is central Pennsylvania, clustered around State College. There sits the main campus of Penn State University, including its agricultural research. Penn State is one of the nation's preeminent

[116] The New York State Science and Technology Foundation, though founded even earlier, in the 1950s, was not originally conceived as an economic-development initiative. It has since been disbanded in favor of a gubernatorial Office of Science, Technology and Academic Research.

examples of a public university "engaged" with its industry constituency and committed to its role in economic development.

STRATEGY OVERVIEW AND DIRECTION

Statewide

Pennsylvania has had an agency and a strategy for technology-based economic development since 1982, when then-Governor Thornburgh created the Ben Franklin Partnership (BFP).[117] Four nonprofit corporations were created to deliver services on a geographically decentralized basis (one center each for Philadelphia, Pittsburgh, State College, and Bethlehem/Allentown). The program reports to a public/private board lodged in the Department of Community and Economic Development, in what is now called the Office of Policy and Technology. Its current appropriation is about $30 million annually.

Unlike other state-level programs of the same vintage, BFP never emphasized large-scale university centers of excellence but rather small-scale matching grants designed to encourage university faculty to participate as partners in the technology-development agendas of small-business enterprises. (The Philadelphia BFP center did support a network of 12 relatively modest centers.[118]) The BFP also invested state appropriations in venture capital, acting as limited partners in a new wave of venture funds set up to be managed in and serve Pennsylvania.

The program underwent some important changes during the subsequent gubernatorial administrations, mostly involving the treatment of manufacturing-extension programs; by the time Governor Ridge took office, its leadership of the state's technology strategy was not assured. Shortly after he took office, Ridge issued a statewide strategy called "Tech 21"[119] and also created a new vehicle, the Pennsylvania Technology Investment Authority (PTIA), to serve as a conduit for appropriations, distributed as either grants or loans.

The Tech 21 strategy focused on six principal "ingredients for success in the new economy":

- **Image**
- **Anchor firms**
- **Venture capital**
- **Workforce**
- **Business climate**
- **Collaboration/networking.**

To assure that it would continue to play a role in executing the new strategy, the network of BFP centers evaluated itself[120] and offered a revised plan designed to track the new strategy. The key feature of the plan was to re-orient the regional BFP centers so that each technology field

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117 For a capsule history, see http://www.gsu.edu/~padiem/pa.html.

118 See http://www.sep.benfranklin.org/services/centers.html

119 See "Technology 21: The Keystone Spirit: Putting Technology to Work." [Harrisburg, 1996]. Available in HTML version on-line at http://sites.state.pa.us/PA_Exec/DCED/tech21/index.htm.

120 See Nexus Associates, Inc. "A Record of Achievement: The Economic Impact of the Ben Franklin Partnership." Harrisburg: Ben Franklin Technology Partners, undated. Available at: http://www.sep.benfranklin.org/who/impactstudy.pdf.

targeted by Tech 21 was the primary responsibility of one particular center. Initial alignments were as follows:[121]

- **Agribusiness sector**—State College
- **Advanced manufacturing**—Allentown/Bethlehem
- **Advanced materials**—State College
- **Biotechnology**—Philadelphia
- **Environmental Technology**—Pittsburgh
- **Information Technology**—Pittsburgh.

This adaptation appears to have been successful: For the 2002 budget cycle, Ridge proposed that the BFP be merged with PTIA to create a new Ben Franklin Technology Development Authority. This new authority would administer

- Continued operation of the decentralized BFP Centers ($28.7 million proposed for FY 2002)
- Statewide investments in technology companies ($10 million proposed for FY 2002)
- Technology development grants to companies and communities ($3 million proposed)
- University research centers—A new initiative for BFP ($14 million proposed).

Another separately budgeted proposal was the Pittsburgh Digital Greenhouse[122], an industry-driven initiative focused on "system-on-chip" technology. The Digital Greenhouse, which has been running for several years, serves as the model for Ridge's last new initiative, the Life Science Greenhouse. The state plans to finance this at $100 million drawn from its share of the tobacco settlement, with activities in each of the regions covered by this profile.

Regional

In the Philadelphia region, strategy is driven by the Eastern Technology Council[123], a membership organization created after Pittsburgh's success with a similar entity; the Greater Philadelphia First Corporation[124], a CEO/leadership group; and the Pennsylvania Economy League—Eastern Division[125], a good-government analytical group. Under the leadership of the latter organization, all three collaborated on a regional strategy for economic growth that stresses its role as a college and university center.[126] Principal components of the regional strategy are

- **Grow the talent base**
    - Market Philadelphia as a center of higher education
    - Expand existing institutions
    - Establish a new, technical, research-based state institution
    - Develop youth-oriented amenities

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121 See http://www.benfranklin.org/assets/indus_grp/execsum_indgrp.pdf.
122 See http://www.digitalgreenhouse.com/about.html
123 See http://www.techcouncil.org/.
124 See http://www.gpfirst.com/
125 See http://www.peleast.org/.
126 See "Greater Philadelphia's Knowledge Industry: Leveraging the Region's Colleges and Universities in the New Economy." Philadelphia: PEL, Fall, 2000. Available at: http://www.peleast.org/knowledge_industry.ZIP.

- **Grow the idea base**
    - Create a research alliance of research institutions and private leaders
    - Build an industry/university consortium in the life sciences
    - Raise a pool of private funds to support endowed chairs
- **Build an identity and image**
    - Maximize development opportunities in the University City neighborhood
    - Market the region as a knowledge hub.

In Pittsburgh, regional technology strategy is shared by several organizations: the Allegheny Conference on Community Economic Development, a CEO/leadership group that led the reinvention of downtown and also hosts the Western Division of the Pennsylvania Economy League[127]; the Pittsburgh Technology Council[128], one of the nation's oldest and now claimed to be the largest; and the Pittsburgh Regional Alliance[129], a coalition of economic-development agencies in the region. The Allegheny Conference has custody of overall regional planning, while the Regional Alliance has sponsored a biomedical initiative.[130] The general thrust of this "BioVenture" initiative is to unite the skills of Pitt and Carnegie Mellon around three business-development thrusts: drug discovery; engineered tissues and organs; and neuroscience therapeutics.[131]

State College has no explicit regional strategy, although it does have a Technology Council of Central Pennsylvania[132] that does mostly marketing work.

R&D BASE

Although the BFP as originally conceived did not include major support to the university R&D base, the reconfigured program does envision a $14 million annual program to help Pennsylvania's already strong universities build their research base and their connections to industry. In addition, the "Life Science Greenhouse" program contemplates investment of $160 million in one-time costs and $60 million a year in R&D costs for three "Greenhouses"—essentially research consortia combined with linked venture capital funds.

Regional

In Philadelphia, both Penn (a private university) and Temple (a state-assisted university) have major academic medical complexes. Penn is known not only for its excellence in basic biomedical science but also as a large center of clinical trials. Its medical center has staked out a strong position in gene therapy, although it also has come under criticism for inadequate safety controls. The Medical College of Pennsylvania is now a quasi-independent unit of Drexel

127 See http://www.accdpel.org/01_01.asp
128 See http://www.pghtech.org/.
129 See http://www.pittsburgh-region.org/public/cfm/aboutus/.
130 See "Pittsburgh's Biomedical Centers for Excellence Identification and Validation." Temporarily not available on-line, but formerly distributed by the Pittsburgh Regional Alliance.
131 See "Pittsburgh BioVenture: Building on a Platform of Scientific Excellence and Entrepreneurial Spirit." Unpublished report.
132 See http://www.tccp.org/about/.

University, a private engineering-oriented school. Other major life-science research assets include the independent Fox Chase Cancer Center, Thomas Jefferson University (a private health-science university), and the Wistar Institute on Penn's campus but independent of the university. Some combination of these institutions will form the core of the Philadelphia version of the Life Sciences Greenhouse.

In Pittsburgh, the principal life-science research assets are the University of Pittsburgh, its Medical Center, and various constituent research centers; Carnegie Mellon University; and several inter-institutional collaborations such as the Pittsburgh Tissue Engineering Initiative. These entities are at the heart of the BioVenture initiative and its effort to capture the Pittsburgh version of the Life Sciences Greenhouse.

In State College, all life-science research activity revolves around Penn State University, the land grant institution and home to the agricultural college and research center. This will likely be the focal point of the third Life Sciences Greenhouse. There are two important anomalies in the geographic alignment of university life-science resources in Pennsylvania: The only state-assisted veterinary school is at Penn, not at Penn State with the agricultural-research complex. Penn State's Medical Center is in neither Philadelphia nor State College, but rather close to Harrisburg in Hershey. A Penn State Life Science Consortium has been created in concert with a new, $43 million life sciences building. It will offer seed grants of between $10,000 and $50,000 for innovative research.

KNOWLEDGE TRANSFER

Regional

BFP awards, which were once nearly uniform statewide, have evolved in different directions according to region. Nearly all awards are now structured as debt, convertible debt, or debt with warrants—rather than the original outright grants. More significant, however, is the evolution away from challenging university and industry scientists to work together and toward seed-stage financing of technology businesses whether or not they work with universities.

In Philadelphia, the Southeastern Pennsylvania Ben Franklin Partnership Center[133] offers four separate award programs, only one of which is in the original model of a university/industry partnership challenge grant: "Technology commercialization" awards may be up to $250,000 and must involve a college, university, or other nonprofit. In Pittsburgh, the Ben Franklin Center, now known as Innovation Works[134], has restructured itself to offer only two seed-capital programs (one debt and one equity) and does not support knowledge transfer activities at all. In State College, the Ben Franklin Technology Center of Central and Northern Pennsylvania[135] still makes its principal focus a Challenge Investment Program that offers awards of up to $75,000, which must be matched 3:1 and repaid by the sponsoring company.

Separately, Penn State operates the Industrial Research Office, which focuses on helping sophisticated, technology-based companies find their way to appropriate R&D resources in the

[133] See http://www.sep.benfranklin.org/.
[134] See http://www.innovationworks.org/.
[135] See http://www.bftc-cnp.org.

Penn State system. One-sixth of Penn State's $440 million R&D budget is industry sponsored—one of the highest proportions in the nation.

TECHNOLOGY COMMERCIALIZATION

Statewide and Regional

At one time the BFP Center in Philadelphia, along with British Technology Group, sponsored a cooperative called START, which was designed to finance commercialization research aimed at intellectual properties held by any of its participating universities. This project has been terminated, however. In all three regions, university technology transfer organizations are very much on their own in raising and applying funding to commercialization research and spin-off formation. Essentially, they must work through their corporate partners, who are eligible for seed-capital support from the BFP centers as they have been reconfigured (see "Risk Capital"). Penn State has created a separate unit, the Research Commercialization Office[136], which works side-by-side with its Intellectual Property Office to focus on formation of start-up firms.

RISK CAPITAL

Statewide

For many years, Pennsylvania public pension funds have invested in venture capital, with an emphasis on funds that are managed in, or invest in, Pennsylvania. As the funds have gained more and more freedom to invest prudently their alternative-asset allocation (so long as reasonable likelihood of benefit to the state or its citizens), they have increasingly participated in start-up of earlier stage and more-targeted funds.

For example, one of the Ridge administration's early moves was to appropriate $20 million from the Public Employee Retirement System (along with $10 million in general appropriations) in a $50 million fund operated by Safeguard Scientifics (NYSE: SFE) called Early Stage Partners.[137] A second fund at $100 million was capitalized by Safeguard and another public pension fund, but not by appropriation. In addition, Ridge has proposed that $60 million of the tobacco settlement be used to capitalize state investment in a similar, privately managed $200 million biotechnology venture fund.

Regional

In Philadelphia, the remaining programs of the BFP center are all pre-seed financing vehicles:

- **Innovation awards** (aimed at product development) of up to $50,000
- **Emerging** (process-development) awards of up to $150,000
- **Technology** improvement awards of up to $250,000.

In addition, the city government has invested $2.5 million in an "Innovation Philadelphia Corporation"—a pre-seed investing vehicle whose exact structure and functioning has not yet

[136] See http://www.research.psu.edu/tt/rco.shtml.
[137] See http://www.paearlystage.com/aboutus.htm.

been fully determined. It recently recruited as its CEO Rich Bendis, formerly the leader of the Kansas Technology Enterprise Corporation.

In Pittsburgh, Innovation Works offers two kinds of pre-seed financing:

- **Innovation investments** (prototype development) of up to $100,000
- **Equity co-investments** of up to $500,000.

Private Sector

Pittsburgh also has seen strong participation by foundation endowments (along with other profit-motivated investors nationwide) in formation venture-capital funds that are based in Pittsburgh and target technologies in which the region specializes, including in the life sciences. Among the most active has been the Benedum Foundation, which has made critical investments in the following new firms: Draper Triangle Venture Fund[138]; Birchmere Ventures[139]; and the Western Pennsylvania Adventure Capital Fund[140], a seed-stage fund.

TECHNOLOGY INFRASTRUCTURE

Regional

By far the most unusual infrastructure element in the Philadelphia region is the University City Science Center[141], a nonprofit corporation established in 1963 and owned consortially by 28 universities, hospitals, and research institutes across three states. The center operates more than 2 million square feet of urban, mostly wet-lab capable, "flex" space on 17 acres near Penn in West Philadelphia. The total capital investment in the center from all sources, public and private, is $140 million of which the Science Center's own equity is $25 million. Space is converted from office to lab or back again as needed. The center operates its own internal research program and claims seven direct spin-offs from that program and 215 that in some way used the facilities of the center. The center now houses 140 companies and nonprofits employing 7,000 in total.

Although it excels at providing space in multitenant technology buildings, for many years the UCSC had no physical business incubator per se, shunning the below-market rent model and preferring a "virtual" or "without walls" approach. With funding from the state and the city's Economic Stimulus Fund, the UCSC has very recently developed a new building housing the "Port of Technology" incubator.[142] The eight-story, $23 million structure houses 150,000 square feet of lab and office space, including wet labs.

Pittsburgh has several important infrastructure elements:

- **The Pittsburgh Technology Center**[143], a former steel mill redeveloped by the city's Urban Redevelopment Authority into a research park housing operations from Carnegie Mellon and regional nonprofits like Innovation Works

138 See http://www.dtvc.com.
139 See http://www.birchmerevc.com.
140 See http://www.wpacf.com/.
141 See http://www.ucsc.org.
142 See http://www.portoftech.com.
143 See http://www.ura.org/maj9.htm.

- **South Side Works**[144], another former mill being redeveloped into a mixed-use research park, featuring the University of Pittsburgh's McGowan Institute for Artificial Organ Development
- A third, adjacent steel-mill site that probably will be purchased by a consortium of foundation endowments organized by the "Strategic Investment Fund"[145] of the Allegheny Conference.

In State College, Penn State operates a 118-acre "Innovation Park"[146] with numerous life-science firms in multitenant or single-tenant structures.

TECHNOLOGY INCENTIVES

Pennsylvania offers an R&D tax credit. In addition, several infrastructure elements like the Port of Technology are located in Keystone Opportunity Zones, with greatly reduced or no tax burdens. The state offers an R&D tax credit.

WORKFORCE

Statewide

Pennsylvania's Higher Education Assistance Authority offers both SciTech (four-year) and Technology (two-year) scholarship programs[147] that fund several thousand dollars in tuition charges in exchange for good grades and participation in internship programs. Overall funding is $24 million annually, but the program is undersubscribed and may be cut.

Regional

Supported by the Ben Franklin Center, the Wistar Institute and the Community College of Philadelphia have jointly developed a two-year training curriculum for biotechnology lab technicians. Students spend 680 hours of paid, employer-based training at Wistar itself.

SUMMARY OF KEY FACTORS

- **Effective leverage of the big pharma corridor**—To the extent the Philadelphia region is succeeding in biotech, one must credit positive feedback between the university research base in the city and the corporate R&D strengths of the suburbs.
- **Unique facility in the University City Science Center**—Although it has come close to failure a few times, the Science Center in Philadelphia is a unique institution: a large and well-established urban research park that is venturing again into business incubation.
- **Wide availability of risk capital**—In both Philadelphia and Pittsburgh there is a broad and deep pool of risk capital at various stages, some of it publicly or quasipublicly managed and some privately managed with public investment.

144 See http://www.ura.org/maj1.htm
145 See http://www.county.allegheny.pa.us/economic/advances/spr2001/investment.asp.
146 See http://www.innovationpark.psu.edu/facilities.html.
147 See http://www.pheaa.org/Find_Money_For_Higher_Education/Scholarships/NETS.shtml.

- **Cross-cutting geographic and sectoral approach**—The state overlays responsibility for particular industry sectors on top of a geographically distributed approach to technology development organizations.

Texas (Houston and San Antonio)

OVERVIEW

By now the story is well known how the business community of Austin (led by the Chamber of Commerce) mobilized in the 1980s to capture the two key federal and private-sector technology-development intermediaries (MCC[148] and SEMATECH[149]) that made Texas a microelectronics center second only to San Jose in Silicon Valley. The Austin initiative involved heavy financial commitments by local companies and philanthropists and by the state through the University of Texas at Austin. In effect, this set the model for technology-led development in the state: minimal coordination from state government and maximum leadership from the local business sector. In a similar way, the business community of Dallas/Fort Worth has vigorously supported the development of the "Telecom Corridor[150]" in the region's suburbs, with a key role played by UT-Dallas, which was established by the UT System with major financial assistance from Texas Instruments Corp.

Although UT-Austin hosts some life-science research, it has no academic medical center; and agricultural research is done in the Texas A&M University System, parallel to and completely independent of the UT System, and headquartered in remote College Station, roughly halfway between Houston and Austin. As a result, life-science leadership has fallen to two of the remaining metropolitan regions: the Houston/Galveston corridor, and in San Antonio, the metropolitan region situated to the southwest of Austin.

As early as the 1980s, the Houston business community had ambitions for a development strategy that would link resources such as the UT Medical Branch in Galveston, the Johnson Space Center, and the cluster of clinical and research institutions (Baylor College of Medicine, Rice University, and UT's M.D. Anderson Cancer Center) that jointly form the Texas Medical Center in downtown Houston. Ironically, although this strategy was intended to help the region diversify away from dependence on energy companies, it may have been the victim of the decline of natural-resource prices later in the decade. Now, the plan has been revived under the leadership of an entrepreneurial president of M.D. Anderson, who also has developed mechanisms to commercialize technologies discovered at Anderson. The region has plans for a Southeast Texas BioTechnology Research Park (detailed in "Technology Infrastructure") and has begun campaigning for state resources.

With a UT academic medical center, an established university-affiliated research park, and an unusual biomedical research foundation, San Antonio is positioning itself as the missing piece of Austin's technology community, focused on the life sciences. Although the infrastructure is established in San Antonio, the culture has yet to fully embrace life science development. However, this appears to be rapidly developing.

148 See http://www.mcc.com/.
149 See http://www.sematech.org/public/index.htm
150 See http://www.telecomcorridor.com/.

STRATEGY OVERVIEW AND DIRECTION

Statewide

Strategy at the state level is not sharply directed. The closest thing to a strategic plan was articulated by an ad hoc Council on Science and Technology, which in 1998 under then-Governor Bush released a strategic plan.[151] This plan was largely aimed at education issues; but to the extent it had substantive recommendations in R&D, they have helped inform various legislative initiatives and appropriations that have passed in the 2001 session, as summarized further below. One proxy for state-level planning has been analytical work conducted by the Federal Reserve Bank of Dallas.[152]

Regional

In Houston, the BioTechnology Park initiative (see "Technology Infrastructure") is driven by a nonprofit corporation assembled by the president of the M.D. Anderson Cancer Center of the UT System, together with the Greater Houston Partnership[153] and the Johnson Space Center[154], and directed by the former president of the Houston Chamber.

In San Antonio, strategy is shared among several organizations:

- **The Southwest Research Consortium**[155] is a coalition of universities and research institutes.
- **SATAI** (San Antonio Technology Accelerator Initiative) Network[156] is a public/private "civic network" of the same nature as Joint Venture Silicon Valley. SATI has taken the lead in articulating a vision for a development future that embraces fast-growing firms in biotechnology and three other clusters.
- **The San Antonio-Austin Life Sciences Association** (SALSA) is promoting a corridor linking the biotech resources of San Antonio with the larger and better known UT-Austin and its network of capital.

R&D BASE

Texas's life-science R&D base includes the UT System, with multiple component campuses; the Texas A&M System;several private universities such as Rice and Baylor College of Medicine; and the Johnson Space Center, which is concerned with performance of the human mission in space. Since 1987, the Texas Higher Education Coordinating Board has offered two competitive, peer-reviewed grant programs aimed at building the R&D base across the state:[157]

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151 See "Report of the Governor's Science and Technology Council," 1998. No longer in print or on Web site.
152 See "Biotech Bonanza: Prospects for Texas." *Southwest Economy.* Federal Reserve Bank of Dallas. Issue 4, July/August 1999. Available on-line.
153 See http://www.houston.org/.
154 See http://www.jsc.nasa.gov/.
155 See http://www.brooks.af.mil/SRC/.
156 See http://satai-network.com/about/
157 Complete RFPs are available at http://www.arpatp.com.

- **The Advanced Research Program** ($20 million in FY 2002–2003), which supports basic research across nine specified target disciplines, and is open to public institutions only
- **The Advanced Technology Program** ($40 million in FY 2002–2003, see also "Knowledge Transfer"), which supports applied research in 12 targeted areas and is open to both public and independent institutions.

In the most recent legislative session, the programs received a joint $10 million increase to $70 million over the next biennium.

In all in the last legislative session, the legislature appropriated $385 million for construction, laboratory expansion, and equipment acquisition for a statewide network of research, science, and engineering facilities, including a San Antonio Life Science Institute that will link the UT campus and the UT Health Science Center in San Antonio, and general support to four UT health science centers.

Finally, the legislature created a Texas Excellence Fund and a University Research Fund to substantially increase research capacity at the state's academic institutions.[158] The fund will be financed with the first $50 million drawn each year from the return on investment of the state's $2 billion higher education fund. According to analysis by the State Science and Technology Institute[159], allocations of $34 million for the 2003 fiscal year are earmarked in the law. Future allocations will be based on the universities' ability to secure additional restricted research funding. Eighty percent will go to the state's strongest universities.

Regional

Houston Advanced Research Center[160] is a stand-alone, nonprofit contract-research institute created in 1982 by oilman George Mitchell as an outgrowth of a conference series he had begun in 1975. Its explicit model is the Research Triangle Institute. Most of HARC's effort is not in the life sciences, but it does maintain an active program in gene chips. HARC's founding members include UT, Rice, Texas A&M, and the University of Houston.

The Southwest Foundation for Biomedical Research[161] represents a similar concept in San Antonio, but more tightly focused on the life sciences. It was founded in 1941 by Texas philanthropist Tom Slick.

KNOWLEDGE TRANSFER

Within the Advanced Technology Program cited previously, up to $8 million in discretionary funds may be allocated to a university/industry challenge grant program. **The Technology Development and Transfer** is open to public and private institutions and requires a 1:1 match from a participating Texas company.

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158 The Excellence Fund is for the 21 schools not supported by the Permanent University Fund, the oil-land endowment that funds UT-Austin and 14 other schools. The Research Fund is for PUF schools other than Austin and Texas A&M in College Station. The sources of funds are different, but both sunset.

159 See http://www.ssti.org.

160 See http://www.harc.edu/history.html.

161 See http://www.sfbr.org/sfbr/about-sfbr/aboutsfbr.html

TECHNOLOGY COMMERCIALIZATION

Statewide

According to the Texas Healthcare and Bioscience Institute, action in the last legislature (SB 1190) authorizes all institutions of higher education to establish centers "to manage, transfer, market or otherwise commercialize technology." It clarifies existing law and broadens the resources that institutions may apply. Governing boards must approve all such decisions or activities, and an annual report is required to the Higher Education Coordinating Board. Currently, the most aggressive commercialization efforts in the UT System are at M.D. Anderson in Houston and the Southwest Medical Center in Dallas. The private Baylor College of Medicine (see below) also is active.

Regional

In Houston, BCM Technologies (BCMT), founded in 1983, is a vehicle created to work closely with the Office of Technology Administration (OTA) of Baylor College of Medicine (BCM). A for-profit commercialization company owned solely by BCM,[162], BCMT helps OTA decide whether a given BCM invention is best commercialized through a straight license or by spin-off; and, in the latter case, it catalyzes formation of a locally based company through a pre-seed investment and provision of interim management services. BCMT also helps recruit stand-alone management and structure in a first-stage investment round, in which BCM itself and other "angel" investors from the region may participate. BCMT is a practitioner of the same "virtual company" model for spin-off formation that also was used until recently by the ARCH Development Corporation at the University of Chicago.

BCMT staff draft the preliminary business plan for a spin-off company, file the papers for formation of the company, and serve as directors and interim executive management of the company. In a typical spin-out deal, BCMT will create a corporation with 1 million shares, of which 150,000 are issued to BCMT in consideration of its services as a commercialization agent, and 850,000 are issued to BCM in consideration of the license to the underlying technology. Of BCM's shares, half are issued under university policy to the inventor(s), who are then discouraged from holding additional founders' equity, serving on the board of directors, or holding any line-management responsibility. At this stage, BCMT may set aside 500,000 additional shares for recruitment of a stand-alone team of professional venture managers, who are identified through a cultivated network of seasoned executives, executive recruiters, and other professional-service providers. At this stage, BCMT may make its first investment of cash, usually a small pre-seed investment (on the order of $50,000 to $100,000) in exchange for convertible loans. This small amount of financing supports the expenses of management recruitment and any commercialization research (proof of concept, prototype production, etc.) that is necessary to raising a larger level of investment.

For what it calls "first round" financing, BCMT turns to a network of regional "angel" investors, corporate partners, and those venture firms interested in early-stage biomedical investing. In many cases syndicates are formed. In some cases, BCM will invest its own institutional

[162] BCM itself is independent of Baylor University and forms the core of the multi-institutional Texas Medical Center in Houston. See http://www.bcm.tmc.edu.

endowment funds at the first round. However, this decision is made on investment merits and not to support BCMT. In this and subsequent rounds, BCMT's pre-seed investment is diluted. Over the past 10 years, 16 BCMT spin-outs have raised more than $300 million in capital from more than 30 different investment groups.

BCMT claims the following key results:

- Merger or acquisition of four BCMT-created companies by 1999, with total deal value of more than $208 million
- Listing of seven BCMT-created companies or their successors on the NASAQ since 1993
- More than 40 percent IRR for "first round" investors since 1990
- Cash income to BCMT and BCM combined of $18 million for 1996–2000, on a portfolio value as of June 2000 of $100 million.

As of last year, BCMT was required to dividend back to BCM any gains it ultimately recognizes, rather than hold them for follow-on investment in other pre-seed deals.

Also in Houston, the President of the M.D. Anderson Cancer Center of UT has established a Cancer Therapeutics Discovery Program[163] with discretionary funding he raised from a major donor. The program is charged to take discoveries farther into development stages (different animal data, etc.) so that an IND (investigational new drug) application can be filed by an industrial partner. On the spectrum of research approaches, this work goes beyond what the NIH calls "translational" or disease-oriented research to which R-01 grants can be applied, but falls short of clinical, patient-oriented research typically underwritten by industry. This program will operate for one or two years on a trial basis, and its future funding has not been determined. Anderson is motivated by a sense that Houston's $1 billion in NIH funding is "buying" it only five start-ups per year, versus dozens for leading biotechnology regions with less funding.[164]

RISK CAPITAL

Statewide

The most recent legislative session funded $45 million in two sources of revolving funding for early-stage businesses in the life sciences:

- A previously suspended **Product Development Fund** ($25 million)
- A **Small Business Incubator Fund** ($20 million).

These programs will be operated by the Comptroller's office under supervision of a gubernatorially appointed board.

Texas has authorized Certified Capital Companies (CAPCOs), but there is as yet no experience base.

[163] An intranet site viewable only from within M.D. Anderson is at http://inside.mdanderson.org/dept/ctdp/.
[164] See presentation by Anderson president John Mendelsohn at http://houstontech.org/uploads/mendelsohn.ppt.

Regional

Texas Capital Network, an Austin-based spin-off of IC^2 Institute [165], is a nonprofit organization that introduces entrepreneurs to investors, supports mentoring, and sponsors annual venture conferences.[166] While UT-Austin is heavily committed to entrepreneurship, relatively little is in the life sciences because this campus has no medical school.

Private Sector

Recently established venture funds focusing on the life sciences in the Houston area include Murphree Venture Partners[167]; Sternhill Partners[168]; Genesis Park[169]; and Cogene BioTech Ventures, started by biogeneticist Thomas Caskey.

TECHNOLOGY INFRASTRUCTURE

Statewide

Best known is Austin Technology Incubator.[170] However, this has no significant life-science component.

Regional

Already operating in Houston is a stand-alone nonprofit business incubator known as the Houston Technology Center[171], which embraces firms in the life sciences as well as energy and information technology. The HTC will be headquartered at a building in the Midtown neighborhood of Houston, being remodeled with a $1.1 million grant from the U.S. Economic Development Administration, matching funds of $750,000 from a local development authority, and from a municipal tax-increment financing district.

Key to Houston's technology infrastructure is the Texas Medical Center[172], a 700-acre, 100-building, 22-million-gross-square-foot complex of both clinical and research facilities owned by 42 separate member institutions, including not only local universities like UT Health Science and M.D. Anderson but also satellite locations of out-of-region universities like Texas A&M's Institute of Biosciences and Technology.[173] Planned for a site adjacent to the Medical Center is the Southeast Texas BioTechnology Research Park.

As currently envisioned, the park will take $633 million and two decades to build out, with 15 separate structures covering 64 acres and eventually housing 23,000 employees. Construction of the park's first building, a $35 million life science center for M.D. Anderson, began in 2001. The state has agreed to contribute $20 million toward infrastructure improvements, although latest

165 See http://www.ic2.org/about.htm.
166 See http://www.thecapitalnetwork.com/.
167 See http://www.murphco.com/.
168 See http://www.sternhillpartners.com/index2.htm.
169 See http://www.genesis-park.com/.
170 See http://www.ic2-ati.org/.
171 See http://houstontech.org/home/index.asp.
172 See http://www.tmc.edu/tmc-introduction.html.
173 See http://www.tamu.edu/ibt/ibtweb/overview.htm.

reports suggest that this will be a loan from the Texas Land Office rather than a grant. Most of the land is state owned and will be leased to the development by the UT System real-estate division via a 20-year contract—a return benefit that has been pointed out to the legislature by the Austin-based Texas Healthcare and Biosciences Institute trade group that argued for grant funding. Participating universities include UT-M.D. Anderson, UT Health Sciences Center, University of Houston, Texas A&M, Baylor College of Medicine, and Texas Southern University.

Although Houston's BioTech Research Park plan is the most ambitious in the state, the life-science infrastructure element farthest along to date is actually the Technology Research Park[174] of West San Antonio, a 1,236-acre facility being developed by a nonprofit foundation. This park houses a variety of small and mid-sized biomedical enterprises and is anchored by the University of Texas Institute for Biotechnology, a unit of the University of Texas Health Science Center at San Antonio. Located outside the park in San Antonio proper is a separate biomedical and bioinformatics incubator, Teksa Innovations.[175]

In Fort Worth, the University of North Texas Health Science Center is planning a $40 million biotech center with commercial space. The project has received a commitment of $27.5 million from the legislature. Tuition revenue bonds would fund the initial 180,000-square-foot building. The Fort Worth MedTech Center, a business incubator, likely would lease space in the development. In nearby Dallas, UT Southwestern Medical Center is planning something similar.

In Bryant-College Station, Texas A&M operates a Research Park[176], with various institutional and food- and agriculture-related research tenants. However, a strong base of agri-biotech firms does not appear in the park or the community.

Technology Incentives

Texas has an Enterprise Zone program and, since 1999, an R&D tax credit available within "Strategic Investment Areas" but not statewide.

Workforce

The Toward Excellence, Access and Success (TEXAS) program provides $20 million in grant support for eligible students attending technical institutes, junior colleges, and public state colleges within the state. Texas also has a marketing program aimed at promoting the importance of college education and a pilot program to support technology training in targeted populations.

Summary of Key Factors

- **Bottom-up leadership**—The major cities of Texas have become technology centers through local business leadership, focused around "civic entrepreneurs" like attorney Pike Powers in Austin or Dr. John Mendelsohn at M.D. Anderson Cancer Center in Houston.

[174] See http://www.trpf.com.
[175] See http://www.teksa.net/
[176] See http://researchpark.tamu.edu.

- **Follow-on state funding**—Responding to local leadership, the state government is prepared to apply significant resources. The wave of bioscience investment by the state has only just begun and has yet to mature.